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DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

PERFORMANCE SPECIFICATION
CATEGORY I/II/III
INSTRUMENT LANDING SYSTEM (ILS)

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APPENDICES

1. SCOPE

The performance requirements specified herein are, for the most part, those requirements contained in Federal Aviation Administration (FAA) Specification FAA-E-2852/b Change 2 and derived from International Civil Aviation Authority (ICAO) Annex 10, Volume 1, Radio Navigation Aids, International Standards and Recommended Practices. The notable areas of exceptions are summarized below:

a. Remote Maintenance Monitoring (RMM) Requirements. These requirements exceed the minimum requirements contained in Annex 10 and are based on FAA maintenance requirements.

b. Localizer Antenna Array Performance. These requirements exceed the minimum requirements contained in Annex 10 and are based on FAA experience in obtaining a quality guidance signal in a high multi-path environment.

c. Remote Control Subsystem. These requirements are tailored to meet interlock requirements of other already fielded equipment in the National Airspace System (NAS).

The Instrument Landing System (ILS) is an instrument approach landing aid that provides guidance to properly equipped aircraft that are making approaches to and landing on airport runways where the ILS is installed. The testing, evaluation, and delivery of all subsystems and equipment that are required for a completed Category I/II/III ILS include a Localizer subsystem, a Glide Slope subsystem, up to three Marker Beacon subsystems, Remote Control subsystem, Localizer Far-Field Monitor subsystem, and a Remote Maintenance Monitor (RMM) subsystem.

2. APPLICABLE DOCUMENTS AND REFERENCES

2.1 Government documents.

FAA SPECIFICATIONS:

[1] United States Department of Transportation, Federal Aviation Administration, *Category II/III Instrument Landing System*, Specification FAA-E-2852/b Change 2, January 25, 1993.

[2] FAA-G-2100g, Federal Aviation Administration *Electronic Equipment General Requirements* as tailored by Appendix A of this specification.

STANDARDS:

<u>FEDERAL</u>:

[3] National Telecommunications and Information Administration (NTIA), *Manual of Regulations and Procedures for Federal Radio Frequency Management*.

[4] FED STD-595, *Colors*.

[5] OSHA 29 CFR 1910.

[6] OSHA 29 CFR 1926.

[7] *Federal Communication Commission (FCC), Rules and Regulations*, Part 2, Part 15, Part 68.

[8] United States Department of Labor Occupational Safety and Health Administration, OSHA 3124 *Stairways and Ladders*, 1993 (Revised).

<u>FAA</u>:

[9] FAA-STD-019d, *Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment*.

[10] FAA-STD-003, *Paint Systems for Structures*.

[11] FAA-910g w/Amendment-1, *Structural Steel*. January 24, 1974.

<u>MILITARY</u>:

[12] MIL-STD-756, *Reliability Prediction*.

[13] MIL-STD-810, *Environmental Engineering Considerations and Laboratory Tests.*

OTHER PUBLICATIONS:

<u>FAA INTERFACE CONTROL DOCUMENTS</u>:

[14] United States Department of Transportation, Federal Aviation Administration, Interface Control Document NAS-IC-51070000-2 *NAS Infrastructure Management System Manager/Managed Subsystem Agent Using the Simple Network Management Protocol Version 3 (SNMPv3).*

FAA ADVISORY CIRCULARS:

[15] FAA Advisory Circular AC 5545-2, *Specification for L-810 Obstruction Lights*.

[16] FAA AC 70/7460-1K, *Obstruction Marking and Lighting 2000*.

[17] FAA Advisory Circular AC 150/5345-43E.

[18] FAA Advisory Circular AC 150/5345-53B Appendix 3.

[19] FAA Advisory Circular AC 150/5300-13.

MILITARY HANDBOOK:

[20] MIL -HDBK-217 *Reliability Stress and Failure Rate Data for Electronic Equipment*.

2.2 Non-Government documents.

EIA STANDARDS:

[1] EIA Standard RS-222, *Structural Standards for Steel Antenna Tower and Antenna Supporting Structures*.

INTERNATIONAL STANDARDS:

[2] *International Standard, Recommended Practices and Procedures for Radio Navigation Aids, Aeronautical Telecommunications, Annex 10 to the Convention on International Civil Aviation*, Fourth Addition of Volume 1, July 1996.

3. REQUIREMENTS

3.1 Equipment comprising an instrument landing system (ILS). This specification describes the following equipment:

a. VHF Localizer Subsystem in paragraph 3.3.1
b. Localizer Far-Field Monitor Subsystem in paragraph 3.3.6
c. UHF Glide Slope Subsystem in paragraph 3.4
d. VHF Marker Beacon Station in paragraph 3.5
e. Remote Control Subsystem in paragraph 3.6
f. ILS Monitor Receiver Subsystem in paragraph 3.7
g. ILS Remote Maintenance Monitor in paragraph 3.8.

3.1.1 Electronic equipment, general requirements. The equipment shall meet the general navigational aid equipment requirements of this paragraph and Table I, tailored from FAA-G-2100, "Electronic Equipment, General Requirements," dated October 22, 2001.

TABLE I. General navigational aid electronic equipment requirements

Requirement	FAA-G-2100 Paragraph	Applicability Notes
Electrical Power	3.1.1	Applies in total
Mechanical	3.1.2	Applies in total
Software	3.1.3	Applies in total
Operating Environmental Conditions	3.2.1	Applies with additional clarification in paragraph 3.2.15 and Appendix A Table A I of this specification
Physical Characteristics	3.2.2	Applies in total
Reliability	3.2.3	Applies except where specified in paragraph 3.2.20 of this specification
Maintainability	3.2.4	Maintainability requirements in paragraph 3.2.18 of this specification Additional maintainability requirements of paragraph 3.2.4 of FAA-G-2100 apply
[Failsafe] External Equipment Interfaces	3.2.5	Applies in total
Electrostatic Discharge	3.2.6	Applies in total

Requirement	FAA-G-2100 Paragraph	Applicability Notes
Materials, Processes, and Parts	3.3.1	Applies in total Additional materials design constraints are in paragraph 3.2.2.2.1 of this specification
Electromagnetic Compatibility (EMI/EMC) and FCC Type Certification	3.3.2	Applies in total Additional requirements for FCC Type Certification of Radionavigational aid transmitters in accordance with Part 87 (47 CFR 87) specified in paragraph 3.2.9 of this specification
Nameplates and Marking	3.3.3	Applies in total
Interchangeability	3.3.4	Applies in total
Personal Safety and Health	3.3.5	Applies in total
Human [Factors] Engineering	3.3.6	Applies in total
Documentation	3.4	Applies as stated in the Statement of Work (SOW)
Personnel and Training	3.5	Applies as stated in the SOW
[Quality Assurance] Quality System Requirements	4.1	Applies as stated in the SOW
[Quality Assurance] Verification/Compliance to Requirements	4.2	Applies in Total except as modified for paragraphs 4.2.2.2 and 4.2.2.4 and the SOW Substitution of Environmental Stress Screening is strongly recommended for Type Testing in paragraph 4.2.2.2, especially when the design includes extensive integration of COTS LRUs
FCC Type Acceptance and Registration Procedures	4.2.2.4	FCC Type Certification and Registration is modified per paragraph 3.2.9 of this specification
Preparation for Delivery	5.0	Applies in total

3.2 General system requirements. This specification applies to the complete ILS. All equipment furnished shall meet the requirements of this specification and the requirements of Specification FAA-G-2100 to the extent specified herein. In the event of a conflict, the requirements of this specification will take precedence over the requirements of Specification FAA-G-2100. The general requirements of paragraphs 3.2.1 through 3.2.29 herein are applicable to the entire ILS unless otherwise indicated.

3.2.1 System performance. The ILS to be provided under this specification shall demonstrate compliance with the airborne measurements specified in the tables below when installed in accordance with FAA standard siting practices. Dual frequency systems shall meet requirements for Category III operation. Single frequency systems shall meet the requirements for Category I operation. A single frequency Glide Slope shall be capable of meeting the requirements for Category II/III operation when installed in accordance with FAA standard siting practices for Category II/III service.

TABLE II. Localizer requirements

ILS Zone	Tolerance/Limit µA		Reference	
	Cat I	Cat II/III	Average	Course Alignment
1	±30	±30	X	
2	±30 to ±15	±30 to ±5		X
3	±15	±5		X
4	N/A	±5		X
5	N/A	±5 to ±10		X

TABLE III. Glide Slope requirements

ILS Zone	Tolerance/Limit µA		Reference	
	Cat I	Cat II/III	Average	Course Alignment
1	±30	±30	X	
2	±30	±30 to ±20		X
3	±30	±20	X	

3.2.2 Equipment physical design and packaging. The equipment shall be designed and packaged in such a manner as to facilitate the accomplishment of all testing, adjustments, and maintenance operations.

3.2.2.1 Subassemblies. Major assemblies or units shall be designed to be completely removable from their enclosures without disassembly and shall be in accordance with FAA-G-2100 paragraph 3.1.2.3.1. Access shall be provided to modules or subassemblies from the front or rear of the equipment cabinet or through the use of swing-out chassis, pull-out drawers with mounting slides, or similar means. If slides are used, they shall be heavy duty, full suspension roller type drawer slides capable of supporting the weight of the equipment without bending, bowing, or coming out of the track.

Slides shall be provided with latching stops to limit the travel of the chassis while allowing complete access to all components when in the extended position. By intentional unlatching of the stops, complete removal of the chassis from the cabinet shall be possible. Cable retractors at the rear of a pull-out chassis shall be provided to allow the slides to be extended to their latch points without disconnecting or damaging any leads or cables.

3.2.2.2 Equipment cabinets. The ILS equipment cabinets shall be sized so that they will fit easily in shelters, leaving room for work space, co-located equipment such as Distance Measuring Equipment (DME), and adequate space for personnel. The minimum dimensions of the localizer and Glide Slope shelters are 8 by 12 feet. Dimensions of the marker beacon shelter are 6 by 8 feet.

The rack or cabinet shall be steel or aluminum. If floor mounted, easily accessible holes in the base shall be provided for attaching the bottom of the rack to the shelter floor. If wall mounted, mounting holes shall be provided for attaching the cabinet to wall-mounted Unistrut or similar material. The rack or cabinet shall allow the installation of as many as four conduits of up to 2-1/2 inch size for AC power, battery, ground, and signal cables. Each cabinet shall be equipped with a GFI duplex receptacle for powering test equipment and tools.

It is desirable, but not required, that wattmeter line sections, distribution and combining networks, attenuators, and phasers be mounted inside the equipment rack rather than in outboard cabinets.

3.2.2.2.1 Materials, processes, and parts. The equipment shall meet the requirements of FAA-G-2100g, paragraph 3.3.1 for materials, processes, and parts. Navigational aids are subjected to environmental service conditions that have been found to be detrimental to several types of material not identified in the "g" version, FAA-G-2100g, so the following sub-paragraphs apply further restrictions to the use of such materials in the design of the equipment:

a. Iron and steel. Iron and steel shall be used only when necessary to comply with strength requirements. Outside equipment enclosures, exposed to Environment III (outside conditions), shall not be made of steel. When approved for use, iron and steel shall be treated to prevent corrosion.

b. Fibrous Material, Organic. Organic fibrous material shall not be used.

c. Fungus-inert Materials. Materials used shall be fungus-inert, except within hermetically sealed assembly. Table IV Group I lists materials that are inherently fungus-inert, and Group II lists materials that are fungus nutrient in some configurations. Materials from Group I are preferred, but when materials from Group II have to be used, they shall be rendered fungus inert by compounding with a permanently effective fungicide or by suitable surface treatment. They shall pass the fungus test specified in ASTM G21, with no visible growth of fungus after 28 days.

d. Insulating Materials, Electrical. Insulating materials shall be selected based on meeting or exceeding the use requirements of the following: temperature endurance, moisture absorption and penetration, fungus resistance, dielectric strength, dielectric constant, mechanical strength, dissipation factor, ozone resistance, and flammability. Polyvinyl chloride insulating materials for external cables shall be in accordance with NFPA-70. Ceramics shall conform to MIL-I-10 or equivalent, and ceramic insulators shall conform to MIL-I-23264 or equivalent. Sleeving shall provide adequate dielectric strength and leakage resistance under the designated service conditions. Cast thermosetting plastic used for electrical insulation shall be in accordance with L-P-516 or equivalent. Other electrical materials having moisture absorption of greater than 1 percent shall be impregnated with a suitable moisture barrier material.

e. Lubricants. Lubricants shall be suitable for the purpose intended. Low volatility lubricants shall be used. The lubricant shall be chemically inert with respect to the materials or other lubricants it contacts. Silicone and graphite base lubricants shall not be used.

f. Rubber (natural). Natural rubber shall not be used.

g. Wood and Wood Products. Wood and wood products shall not be used inside equipment.

h. Thread Locking and Retaining Compounds. Thread locking and retaining compounds shall conform to the required operating conditions and shall be applied such that the required level of locking or retaining is achieved and maintained. Compounds shall not impair electrical conductivity, cause or accelerate corrosion, or be used where failure would endanger personnel or damage equipment, and such compounds shall be compatible with the material to which they are bonded.

i. Antiseize Compounds. Antiseize compounds shall conform to MIL-T 22361 or TT-S-1732 or equivalent. Graphite base antiseize compounds shall not be used.

TABLE IV. Fungi susceptibility of material

GROUP I. Fungus-inert Materials	GROUP II. Not Fungus-inert
Acrylics	ABS (acrylonitrile-butadiene styrene)
Acrylonitrile-styrene	Acetal
Acrylonitrile-vinyl-chloride copolymer	Cellulose acetate
Ceramics	Epoxy-glass fiber laminates
Chlorinated polyether	Epoxy-resin
Florinated ethylenepropylene copolymer (FEP)	Lubricants
Glass	Melamine-formaldehyde
Metals	Organic polysulphides
Plastic laminates:	Phenor-formaldehyde
Silicone-glass fiber	Polydichlorostyrene
Phenolic-nylon fiber	Polyethylene, low and medium density (0.940 and below)
Diallyl phthalate	Polymethyl methacrylate
Polyacrylonitrile	Polyurethane (the ester types are particularly susceptible)
Polyamide	Polyrichinoleates
Polycarbonate	Polyvinyl chloride
Polyester – glass fiber laminates	Polyvinyl chloride-acetate
Polyethylene, high density (above 0.940)	Polyvinyl fluoride
Polymonochlorotrifluoroethylene	Rubbers, natural and synthetic
Polypropylene	Urea-formaldehyde
Polystyrene	
Polysulfone	
Polytetrafluorethylene	
Polyvinylidene chloride	
Silicone resin	
Siloxane-polyolefin polymer	
Siloxane-polystyrene	

3.2.3 Controls and indicators. Single (Category I) systems may utilize the same control panel as a dual system; however, all indicator lights which do not apply shall remain OFF (not illuminated) except during lamp test. All switches which do not apply to a single transmitter/monitor subsystem shall have no effect on the operation of the equipment in any way.

Note: A "switch" is a physical device with a mechanical actuator located on the equipment and operable without connecting an outboard computer. A "control" can be either a physical switch or a function controlled by a connected computer. The following front panel controls and indicators shall be provided.

a. A switch to turn the transmitter output radiation ON and OFF. This function shall also be available at the Remote Status and Control Unit.

b. A switch at the transmitter to disable remote control of the transmitter on/off function.

c. A switch or control on dual transmitter equipment to toggle the Main and Standby function between the two transmitters and to disable the standby transmitter if desired.

d. For test purposes, a switch to bypass monitor action, allowing the transmitter to remain on the air in an abnormal state.

e. On dual frequency systems, a control to independently remove the clearance transmitter signal without affecting the course transmitter.

f. A control or controls to turn ON or OFF each of the modulation tones individually. In addition to individual control of the modulation tones, a single control to switch both tones simultaneously is desirable but not required.

g. A reset switch to initialize the system to its normal power-on operating state.

h. A Lamp Test switch which causes all installed front panel indicator lamps, including those normally inactive in a single-equipment system, to illuminate, so as to avoid confusion with "dark" lamps when performing this test.

Front panel indicator lights shall be provided for, at minimum, the following functions:

a. Power on
b. Power source (Main/AC or standby/batteries)
c. On-air (radiating) status of the main transmitter
d. Ready status of the standby transmitter on a dual system
e. Indication of which transmitter is currently radiating
f. Indication of manual monitor bypass
g. Indication of local (only) or local/remote control status
h. Indication of monitor normal/alarm status.

The following colors shall be used for indicators:

Green – normal operation
Amber – alert condition
Red – Alarm condition.

3.2.4 <u>Display and adjustment of parameters</u>. A front panel alphanumeric display, touch screen, or a portable terminal (not to be furnished under this specification) connected to the subsystem terminal interface shall be capable of displaying all control settings and data. Each parameter and its current value shall be displayed in an easily readable format. For the purpose of making adjustments, the parameter to be adjusted shall be selectable by cursor or menu. If the display system requires operator input in order to make adjustments, on-screen help shall be provided. The smallest increment for adjustment of a parameter shall be consistent with the tolerance for that parameter. If adjustment is performed via a keyboard or numeric keypad, it shall be possible to directly enter a numeric value in addition to or in lieu of setting by scrolling through a series of displayed values.

3.2.4.1 Use of a portable maintenance data terminal (PMDT). A PMDT (paragraph 6.1.24) connected to the subsystem terminal interface may be used for displaying all control settings on a neatly formatted screen or screens with the parameter name and its current value clearly displayed. Any necessary PMDT application software shall be provided by the contractor. The PMDT software shall be a 32-bit application capable of running under Windows 2000.

3.2.5 Parameter resolution. The displayed resolution of a maintenance parameter shall be consistent with that parameter's tolerances as illustrated in the table below unless greater resolution is required for a maintenance procedure unique to the equipment supplied under this contract. Sufficient resolution of data entry and display shall be provided such that the digitization error of an entered value is less than the rounding error of the least significant digit displayed or entered. For example, if a parameter is displayed with a resolution of hundredths of a unit, when a value of 123.45 is entered by the operator, the stored is between 123.445 and 123.455, and the displayed value is 123.45.

TABLE V. Parameter resolution

Parameter	Resolution	Example
Power ≥ 10 W	Tenths	14.7 W
Power < 10 W and ≥ 1W	Hundredths	2.63 W
Power < 1W and ≥ 100 mW	Units	215 mW
Power < 100 mW	Tenths	18.5 mW, 4.5 mW
Voltage ≥ 100 V	Units	124 V
Voltage < 100 V	Tenths	12.2 V, 5.2 V
Modulation %	Tenths	20.1 %, 7.9 %
Modulation balance (DDM)	Thousandths	0.003 DDM, 0.156 DDM
Audio Frequency	Units	1015 Hz, 89 Hz
Radio Frequency (dual frequency separation)	Tenths	7.8 kHz

3.2.6 Reserved.

3.2.7 Adjustment and storage of entered parameter data. Adjustments shall be of an essentially permanent nature. Mechanical adjustments shall be lockable (for example, shaft locks, detented control positions). Electronic adjustments shall be stored in non-volatile media (90 days minimum retention) with settings recalled and restored automatically upon restoration of system power.

3.2.7.1 Storage of entered data. Electronically entered control settings shall become effective either immediately upon entry or at the conclusion of an adjustment/maintenance operation by pressing a STORE or ENTER key or button as appropriate for the parameter or control setting. If adjustable parameters have been changed, prior to returning the equipment to normal operation, the operator shall be prompted to save the new settings. In the event that the operator chooses not to save the changes, the last-saved settings should be restored.

3.2.8 Reserved.

3.2.9 Electromagnetic interference (EMI) control. Spurious RF energy applied to the antenna transmission line under normal operating conditions shall be more than 60 dB below the power of the fundamental (carrier) energy. With each transmitter terminated into a dummy load or a properly terminated cable, under any operating conditions, the stray on-frequency radiation from the Localizer or Glide Slope equipment shall be less than or equal to 5.0 μW, or from the Marker Beacon shall be less than or equal to 1.0 μW effective radiated power (ERP). The equipment manufacturer or supplier shall obtain Federal Communication Commission (FCC) type acceptance in accordance with FCC Rules and Regulations, CFR, Title 47, Part 2, 15, and 87. The environmental temperature range, specified by the FCC, supersedes for the purposes of the FCC Type Acceptance Procedures, the service conditions temperature range, which is applicable under this specification. For equipment designed for connection to either the public or private telephone networks, the contractor shall obtain FCC Registration in accordance with FCC Rules and Regulations, Part 68. All components of the RMM subsystem shall meet the requirements for Class A computing devices in accordance with subpart B, Part 15, and certification in accordance with subpart J, Part 2 of the FCC Rules and Regulations.

3.2.9.1 Electromagnetic compatibility. In addition to the requirements of FAA-G-2100, paragraph 3.3.2 for electromagnetic compatibility (EMI/EMC), the vendor shall meet the requirements of CFR Title 47 Part 87 (Telecommunications, Federal Communications Commission, Part 87, of the FCC Rules and Regulations) for all equipment that radiates in the frequency bands protected for radio navigation.

3.2.10 Transmitter RF power sampling. Means shall be provided to sample and display (locally on the front panel or with a PMDT and remotely through the RMS) forward and reverse RF power of each ILS transmitter's outputs (CSB and SBO). Repeatability and long-term stability shall be ±2 percent. The RF power sampling point shall be located electrically beyond any phasers, attenuators, and (on dual transmitter systems) RF transfer relays. In a dual transmitter hot standby system, the power delivered to the dummy load shall also be measured and indicated.

3.2.11 Transmitter internal RF power measurement. A method and procedure shall be provided to calibrate internal power sensors to an external RF power meter. The internal RF power measurement function shall be capable of adjustment so that at the normal operating power, internal and external power readings match to within the resolution of the internal sensor readout. Linearity of the internal sensors shall be such that their readings track the actual RF power as measured externally to an accuracy of ±2 degrees over the range from normal (calibrated) power to 4dB below normal power.

3.2.12 Voltage regulators. External voltage regulating transformers shall not be used.

3.2.13 Transient protection. The equipment shall be protected against damage or operational impairment resulting from induced transients on any ungrounded AC power line, communication, control, signal, or monitor line entering or leaving the subsystem or equipment shelter or ancillary unit in accordance with FAA Standard 019d and paragraph 3.1.1.6.f of Specification FAA-G-2100. For design and test purposes, the contractor may assume that the subsystem shelters will be equipped with surge arresters installed between each AC power line and neutral at the main service disconnect box in accordance with FAA Standard 020.

3.2.14 Output circuit protection. All equipment output circuits and transmitter RF output circuits shall be protected in accordance with the requirements of paragraph 3.1.1.8 of Specification FAA-G-2100 such that operation into an open circuit or short circuit does not cause damage to the equipment.

3.2.15 Environmental service conditions. Environmental service conditions are defined in Appendix A of this specification. Localizer, Glide Slope, and Marker Beacon transmitter subassemblies shall meet requirements of Environment 2. Antennas and distribution/monitoring components which are not enclosed in an environmentally controlled shelter shall meet requirements of Environment 3. Unless otherwise stated, all requirements of this specification shall be met over the full range of service conditions appropriate for the equipment described.

3.2.16 Primary power. All equipment provided under this specification shall operate from nominal 120 volts single phase 60 Hz commercial power and over the range specified in FAA-G-2100, paragraph 3.1.1.7.

3.2.17 Standby power. All equipment, including the Remote Status and Control Unit, shall be equipped with a standby battery power system to provide uninterrupted operation if primary power is lost.

Batteries are not to be supplied under this specification; however, the equipment manufacturer shall specify the battery voltage, and capacity required for the operation stated above.

A mounting shelf for the recommended batteries shall be provided as specified in paragraph 3.3.1.3.1 of FAA-G-2100.

A battery charging system to maintain the batteries when operating on primary power shall be provided.

An automatic shutdown shall be provided to prevent damage to the equipment or batteries when the battery voltage falls below a preset threshold.

The battery or batteries shall, when fully charged, be capable of powering the Localizer or Glide Slope for at least 4 hours and the Marker Beacon and Far-Field Monitor for at least 72 hours. Localizer and Glide Slope batteries shall recharge to full capacity in 6 hours or less after operating the ILS equipment for one-half the manufacturer's stated battery operating time (50 percent usage capacity). Marker Beacon and Far-Field Monitor batteries shall fully recharge from 50 percent usage capacity to full capacity in 24 hours or less. Remote Status and Control Unit batteries shall provide the same operating time and require the same recharge time as Localizer and Glide Slope batteries. Batteries shall be of a sealed electrolyte type.

With the exception of standby power changeover operation, the system shall meet all performance requirements when operating on batteries.

Upon restoration of primary power the station equipment shall continue normal operation or, if secondary power has been expended, automatically initiate start-up operational action.

3.2.17.1 Battery disconnect switch and fuse/circuit breaker. All field equipment (Localizer, Glide Slope, Marker Beacon, and Far Field Monitor) shall be furnished with a manually operated battery disconnect switch to remove battery voltage from the transmitting equipment. This switch shall employ a hardware interlock (i.e., the switch is returned to its normal ON position when maintenance access is secured) or alternately, a front panel mounted amber Maintenance Alert indicator shall illuminate when the battery is disconnected from the equipment. The indicator serves as a visual reminder that the equipment is unable to operate from battery power. A fuse or circuit breaker shall be provided to prevent excessive current flow to or from the battery. The switch and circuit breaker may be combined in a single part.

3.2.18 Maintainability of electronic equipment.

3.2.18.1 Corrective maintenance requirements. The Mean Time to Repair (MTTR) of any subsystem shall be less than 30 minutes. For purposes of this specification, Time to Repair includes diagnostic time; disassembly and removal of the failed LRU; replacement and installation of the new LRU including any adjustments; loading of data necessary to initialize the system after LRU replacement; and verification required to return the ILS to normal operation.

3.2.18.2 Preventive maintenance requirements. Ninety-five percent of all routine maintenance procedures required for the ILS shall be accomplished in less than 15 minutes. No single group of periodic maintenance procedures shall require more than 2 hours to complete or be required more frequently than every 3 months.

3.2.19 Special tools and test equipment. Any special tools, test equipment, or test cables required for testing or maintenance shall be provided by the contractor.

3.2.20 Reliability of electronic equipment. Each ILS subsystem or equipment group shall exhibit the reliability figures specified below.

3.2.20.1 Localizer MTBF. The Localizer subsystem shall have a specified MTBF of not less than 4000 hours as a serial reliability model.

3.2.20.2 Glide Slope MTBF. The Glide Slope subsystem shall have a specified MTBF of not less than 4000 hours as a serial reliability model.

3.2.20.3 Marker Beacon MTBF. The individual Marker Beacon subsystems shall each have a specified MTBF of not less than 10,000 hours as a serial reliability model.

3.2.20.4 Localizer Far-Field Monitor (FFM) MTBF. The FFM subsystem shall have a specified MTBF of not less than 10,000 hours as a serial reliability model.

3.2.20.5 Remote Control subsystem MTBF. The remote control equipment group (RSCU and RSIC) shall have a specified MTBF of not less than 20,000 hours as a serial reliability model.

3.2.21 Continuity of service. The continuity of service of the Localizer and Glide Slope (expressed as a probability of not losing the radiated guidance signals) shall be equal to or greater than the requirements shown in Table VI.

3.2.22 Integrity of signal. Integrity of the signal (expressed as a probability of not radiating false guidance signals) shall be equal to or greater than the requirements shown in Table VI.

TABLE VI. Integrity and continuity of service

Category	**Localizer and Glide Path**		
	Integrity	**Continuity of Service**	
Single Equipment	1 - 10^{-7} in any one landing	1 - 4 x 10^{-6}	
Dual Equipment	1 - 0.5 x 10^{-9} in any one landing	1 - 2 x 10^{-6}	(any period of 30 seconds for Localizer) (any period of 15 seconds for Glide Slope)

3.2.23 Failsafe. The monitoring of the ILS shall be fail-safe such that failure of any part of the monitor subsystem either results directly in an alarm condition, or does not alter any alarm threshold level so as to allow an out-of-tolerance condition to occur without detection. For such parts as electronic or electromagnetic switching devices where it is not practical to provide failsafe operation under both modes of failure (open circuit and short circuit), failsafe protection shall be provided for the mode of failure having the higher probability.

3.2.24 Antenna support structure design. The design, manufacture and workmanship, factory finish, plans and markings, foundation designs, and protective grounding for steel towers and supports shall be in accordance with EIA Standard RS-222, FAA Specification FAA-910 and FAA Standard 019. Heights of towers and platforms shall be as indicated in the subsystem antenna requirements set forth herein. The wind and ice loading conditions for all towers and supports shall be as specified for Environment III of Appendix A of this specification (modifies EIA Standard RS-222 for this application). All steel members, including hardware, shall be hot dip galvanized after fabrication. Foundations shall be designed for soil pressure of 3000 pounds per square foot.

3.2.24.1 Marker Beacon and Far-Field Monitor antenna mounting. Self-supporting steel towers shall be provided for mounting the middle and outer Marker Beacon antennas. A frangible, self-supporting mounting pole shall be provided for the inner Marker Beacon and Far-Field Monitor antennas.

3.2.24.2 Localizer antenna mounting. The complete Localizer antenna array shall be designed for installation on a concrete foundation in the ground or on an elevated platform support. The antenna array support structure (foundation or elevated platform) is not furnished under this specification. Each individual antenna shall be mounted on two self-supporting frangible pedestals.

3.2.24.3 Glide Slope tower. A self-supporting Glide Slope tower shall be comprised of sections that allow adjusting the height of the tower in increments for each of the configurations with no more than 5 feet of tower extending beyond the upper antenna. The tower shall have a climbing ladder and safety hardware meeting all OSHA 3124 and 29 CFR 1910.27 safety requirements. Obstruction lights, air terminal (lightning) rods, and antenna hardware shall be furnished in the installation kit.

3.2.24.4 Antenna tower and support finishes. All towers and antenna supports shall be painted in accordance with FAA Advisory Circular 70/7460-1. Glide Slope towers shall be painted in an obstruction-marking pattern of alternating aviation orange, color 12197 and insignia white, color 17875 in accordance with Federal Standard 595. Painting and finish of all towers and supports shall be in accordance with FAA-STD-003.

3.2.25 Status monitoring of co-located electronic equipment. An input for a contact closure or TTL level of either sense shall be provided to allow local display and transmission to the Remote Status and Control Unit (paragraph 3.6.1.2) of the operational status (NORMAL or ALARM) of co-located equipment such as a DME installed in a Localizer shelter or an NDB co-located with a Marker Beacon.

3.2.25.1 Auxiliary input pass-through. In order to accommodate auxiliary equipment such as a DME serving multiple runways with interlocked ILS equipment, the auxiliary inputs shall be configurable so that the status of the connected equipment is passed to the RSCU when the ILS is interlocked off-the-air but is still powered on and under RSCU control.

3.2.26 Dual equipment. For a dual equipment system, the same requirements shall be met by both the main and standby transmitters and monitors.

3.2.27 Personnel safety requirements. Paragraphs 3.4.5.14.4 and 3.2.24.3 contain specifications related to safety of personnel when working near or on the Glide Slope Antenna Tower.

3.2.28 Security requirements. The contractor will ensure that appropriate security safeguards are incorporated into the equipment as described below.

3.2.28.1 Data security. The Category I/II/III ILS System shall contain features in its design and operation that prevent unauthorized and disruptive access to the system by implementing the following requirements as a minimum:

a. Authorized user access verification

b. User password control

c. Restriction of access to system/Operating System (OS) files/data

d. Denying access to direct OS functions/commands

e. Logging of unauthorized system access attempts

f. Lockout of the log-in process for 15 minutes following three consecutive unsuccessful log-in attempts

g. Limiting access to specific functions based on job category

h. While in the normal operating mode, prevent loading of data from removable media or network connections

i. Disable any unused interface ports during normal operation.

RMS security specifications are provided in paragraph 3.8.10 of this document.

3.2.28.2 Physical security. The ILS shall incorporate security features consistent with facility security requirements. The ILS security detection methods and reporting procedures shall be designed so as to minimize the occurrence of false security alarms without compromising facility security.

3.3 Localizer equipment requirements. Typically, Category I installations typically employ a single equipment localizer in one of the three antenna configurations, while Category II/III installations employ dual equipment in the dual frequency configuration. The Localizer chassis, cabinet, and card cage shall be mechanically designed and prewired (power, control, data, backplane) to accept additional modules allowing any configuration to be field-convertible to any other configuration including conversion to dual frequency and dual transmitter/monitor configurations.

3.3.1 VHF Localizer subsystem. A completely equipped VHF Localizer station will typically consist of the following equipment as specified in the Statement of Work:

a. For Category II/III installations: Dual (main and standby) course and clearance transmitters with associated modulation and control equipment, with the clearance transmitter being identical in design and construction to the course transmitter with the exception of the carrier frequency.

b For Category I installations: Single or dual equipment, single or dual frequency transmitter with associated modulation and control equipment.

c. Localizer antenna array with associated feed and integral monitor cabling, stripline or microstrip signal distribution units, integral monitor pickup devices and stripline or microstrip combining units, obstruction lights, and antenna element support structures. One of the three Localizer antenna types described in paragraph 3.3.4 will be specified when ordering.

d. Dual Localizer monitor for Category II/III ILS equipment and single monitor for Category I ILS equipment.

e. Far-Field Monitor subsystem for Category II/III equipment.

3.3.2 VHF Localizer station performance. The VHF Localizer subsystem shall provide guidance in the horizontal plane to aircraft in approaches to, and landings at airfields. The radiation from the Localizer antenna group shall produce a composite field pattern that is amplitude modulated by a 90 Hz and a 150 Hz tone and 1020 Hz identification tone. The radiation field pattern shall produce a course sector with one tone predominating on one side of the course centerline and the other tone predominating on the opposite side. When facing the Localizer antenna from the approach end of the runway, the 150 Hz tone shall predominate on the right hand side of centerline and the 90 Hz tone shall predominate on the left hand side. All horizontal angles employed in specifying the Localizer field patterns shall originate from the center of the Localizer antenna group which provides the signals used in the front course sector.

3.3.2.1 Coverage. With the transmitter power output reduced to the monitor RF level alarm point (-1 dB for Dual Frequency, -3 dB for Single Frequency), the Localizer coverage sector shall provide a signal strength of 5 microvolts at a flag current of 240 microamperes and in-tolerance clearance at the ICAO standard service volume distances of 25 nautical miles within ± 10 degrees of the course line and 10 nautical miles within ±35 degrees of the course line. Coverage beyond ±35 degrees is not required. The localizer signal shall be receivable at the distance specified at and above the height 1500 feet above the elevation of the threshold or 1000 feet above the elevation of the highest point within the intermediate and final approach areas, whichever is higher. Such signals shall be receivable to the distance specified, up to a surface extending outward from the Localizer antenna and inclined 7 degrees above the horizontal. Coverage measurements will be made by a certified FAA flight inspection aircraft.

3.3.2.2 Polarization. The Localizer radiation shall be horizontally polarized. The vertically polarized component of the radiation shall result in no errors in course alignment greater than 0.005 DDM when the aircraft is flying along the course line in a roll attitude of 20 degrees from the horizontal.

3.3.2.3 Course alignment accuracy. Based on a nominal sector width of 700 feet at threshold, the mean course line shall be capable of being adjusted and maintained to within limits equivalent to 10 feet from the runaway centerline at the ILS reference datum.

3.3.2.4 Displacement sensitivity. The nominal displacement sensitivity within the half course sector at the ILS reference datum shall be 0.00044 DDM/foot, based on a nominal sector width of 700 feet at the ILS reference datum. The increase of DDM shall be substantially linear with respect to angular displacement from the front course line up to an angle on either side of the front course line where the DDM is 0.180. From that angle to ±35 degrees, the DDM shall be less than or equal to 0.155. When the course width is increased to the wide alarm limit (typically 10 to 14 percent), the DDM shall be less than or equal to 0.155 from 4 degrees to the limits of coverage.

3.3.2.5 Course sector width. The Localizer course sector width shall be easily adjustable over the range of 2.1 to 7.0 degrees to allow tailoring to a 700 foot runway threshold course sector width at a typical runway installation. For dual frequency Localizer configurations, the course sector width of the clearance array shall be easily adjusted to a nominal width that provides smooth transition from the course signal to the clearance signal and that provides maximum clearance signal outside of the normal Localizer course sector.

3.3.2.6 Automatic changeover unit (dual transmitter/monitor systems only). The transmitter shall be equipped with an automatic changeover unit, which is controlled by the monitor. When a fault is detected, the automatic changeover unit shall transfer the antenna signals to the standby transmitter.

3.3.3 Localizer transmitter. A Localizer transmitter includes the following major functional components: RF generator, modulator, identification keyer, and remote monitoring sensors. Specific requirements are given in the following paragraphs.

3.3.3.1 Radio frequency. The transmitter frequency shall be controlled by a crystal-referenced synthesizer adjustable over the full frequency range of 108 to 112 MHz in steps of .05 MHz. The accuracy of the carrier frequency shall be within ±0.002 percent. For a single-frequency Localizer, the course frequency shall be the assigned (channel) frequency. For a dual frequency Localizer, the frequencies of the two RF carriers shall be locked together, requiring only a single setting to select the Localizer nominal operating frequency. The two transmitters shall be offset symmetrically about the assigned (channel) frequency with a nominal frequency difference of 8 kHz, but not less than 7.5 kHz or more than 8.5 kHz.

3.3.3.2 Modulation. The nominal depth of modulation of the radio frequency carrier of each of the 90 Hz and 150 Hz tones shall be 20 percent and shall be maintained within the limits of 19 and 21 percent.

3.3.3.3 Identification. In addition to the 90 and 150 Hz navigation tones, the Localizer shall simultaneously modulate the RF carrier with a keyed 1020 Hz ±50 Hz tone for the purpose of aurally identifying the Localizer station at the airborne ILS receiver. The transmission of the identification signal shall interfere in no way with the basic Localizer function. The identification signal shall employ the International Morse Code and shall normally consist of four letters, the letter "I" followed by the three letter code assigned to the Localizer station. The identification signal shall be transmitted at a speed corresponding to approximately seven words per minute, and shall be repeated at approximately equal intervals, not less than six times per minute, at all times during which the Localizer is available for operational use. A control to remove the identification signal or transmit a continuous tone for test and adjustment purposes shall be provided. A means for local audible monitoring of the identification signal shall be provided by the transmitter.

3.3.3.4 Transmitter output power and adjustment. The transmitter of any subsystem shall have sufficient power to meet the coverage requirements as defined in paragraph 3.3.2.1 with the antennas provided when properly installed at a site meeting the FAA Localizer siting criteria. For purposes of testing, the transmitter output power shall be capable of being reduced below maximum power output by at least 4 dB without changing the modulation characteristics of the transmitted signal and without the temporary installation of attenuators. The output power of the CSB signal shall be adjustable with resolution no coarser than 0.1 watts.

When operating at the reduced (-4 dB) power level:

a. Modulation balance shall be changed by no more than 0.002 DDM
b. Course width shall be changed by no more than 2 percent
c. Carrier total modulation percentage shall change by no more than 1

percent in absolute value (typically 39 to 41 percent)

d. Localizer Identification modulation shall change by no more than 0.8 percent in absolute value (typically 7.2 to 8.8 percent).

3.3.3.5 Transmitter stability. Variations in the following parameters over the service conditions shall be equal to or less than the limits tabulated below:

a.	Carrier power at carrier output	±5.0 percent
b.	Sideband ratio	±0.5 dB
c.	Carrier modulation	±1 percent (each tone)
d.	Carrier modulation balance	±0.002 DDM
e.	Sideband balance	±0.3 dB
f.	RF phase between carrier and sideband outputs	±10 degrees
g.	Navigational tone frequency	±1.0 percent
h.	Transmitter carrier frequency	±0.002 percent

The above requirements shall be met for any setting of sideband amplitude between 20 mW and 500 mW.

3.3.3.6 Power-on stabilization time. Stability requirements of paragraph 3.3.3.5 shall be met from 0.5 seconds after power-on or transfer between transmitters of a dual transmitter system.

3.3.3.6.1 Hot standby transmitter(s). If Localizer subsystem stabilization requirements specified in paragraph 3.3.3.6 cannot be met with the standby transmitter normally inoperative ("cold"), the subsystem shall be designed so that the standby transmitter is continuously operating into a dummy load and is continuously monitored.

3.3.3.7 Transmitter control functions and indicators. Controls and indicators shall be provided as described in paragraph 3.2.3.

3.3.3.8 Audio phase of modulation tones. Audio phase relationship of the 90 Hz and 150 Hz modulation tones is as follows:

a. The relative phase of the 90 Hz and 150 Hz modulation tones of the course transmitter shall be such that the demodulated 90 Hz and 150 Hz waveforms pass through zero in the same direction within 50 microseconds of each other at the common zero crossing. If wavetable or other digitally synthesized method is used to produce the composite modulation waveform, sample rate and resolution shall be sufficient to meet these criteria.

b. The phase of the 150 Hz modulation tone of the clearance transmitter, relative to the 150 Hz modulation tone of the course transmitter shall be phase-locked so that the demodulated waveforms pass through zero in the same direction within 50 microseconds at every zero crossing.

c. An adjustment shall be provided to offset the phase relationship between the course and clearance audio modulation by up to 90 degrees for the purpose of improving immunity reflections. The established offset phase relationship shall be lockable to within 50 microseconds.

3.3.3.9 Carrier modulation. A control shall be provided to adjust total modulation of the carrier output signals in steps of 0.1 percent or smaller over a minimum range of 34.0 to 46.0 percent. RF phase between carrier and sideband outputs shall remain stable within 5 degrees when modulation is adjusted over this range. The modulation balance shall remain constant within ± 0.004 DDM throughout the full specified range of the total modulation percentage adjustment.

3.3.3.10 Distortion of demodulated navigation tones. Total harmonic distortion of the detected modulation shall be less than 5 percent measured over the bandwidth of 30 Hz to 4 kHz. In addition, no single multiple of 30 Hz within that range with the exception of the 90 and 150 Hz modulation tones shall have an amplitude greater than 4 percent (-28 dB) of the maximum amplitude of the demodulated audio.

3.3.3.11 Modulation balance adjustment. A control shall be provided for precisely adjusting the total modulation balance (ratio between 90 Hz and 150 Hz amplitudes), and for simulating changes in the Localizer course position. The control shall have sufficient range to enable the Localizer to be adjusted to meet the requirements specified in paragraph 3.3.2.3. The total modulation percentage shall remain stable within 0.1 percent when the modulation balance is adjusted over a range of ±0.025 DDM.

3.3.3.12 Identification keyer. The transmitter shall include a solid-state electronic keyer that modulates the carrier with a 1020 Hz tone to a nominal depth of 8 ±1 percent without interruption of the carrier. The keyer shall provide character timing as follows:

a.	Dot length	0.125 second
b.	Dash length	0.375 second
c.	Space between a series of dots and dashes within a character	0.125 second
d.	Space between characters	0.375 second

The keying rates shall remain within ±15 percent of the specified values under the service conditions of temperature and humidity. Keying pulses shall start without undesirable transients, shall have no discontinuities, and shall stop without undesirable transients. Transient peaks due to keying shall be less than or equal to 2 percent of the peak amplitude of the normal audio frequency waveform at the modulator output. A multi-position switch or control shall be provided to enable selection of either keyed or unkeyed modulation or to remove all identification modulation from the carrier.

3.3.3.13 Sideband amplitude adjustment. A sideband amplitude control shall be provided to enable adjustment of the Localizer course sector width over the range specified in paragraph 3.3.2.5. Adjustment of this control over its range shall change the carrier to sideband phasing by no more than 5 degrees as measured over the service conditions of temperature and humidity.

3.3.3.14 RF phase adjustment. A phasing control shall be provided for shifting the RF phase of the signals appearing at the sideband (SBO) output over a range of at least ±20 degrees from the carrier (CSB) signal. Adjustment of this control over its full range shall cause the sideband amplitude to change less than or equal to ±0.25 dB.

3.3.3.15 Carrier signal at sideband output. With the modulator adjusted for optimum conditions, for any combination of sideband amplitude control or sideband phaser control settings, the carrier (CSB) power appearing at the sideband (SBO) output shall be 30 dB or more below the carrier power appearing at the carrier (CSB) output.

3.3.3.16 Power and modulation measurements. Means shall be provided to measure course and clearance carrier and sideband powers and carrier modulation percentage. Built- in line sections for wattmeter elements shall be installed in each of the output CSB and SBO lines to allow the measurement of modulation and modulation balance with external test equipment. For dual equipment, the line sections shall be installed after the transfer relays.

3.3.3.17 DME keying output. The Localizer shall provide an output for identification keying of an associated DME (not part of this solicitation). When DME keying is selected, every fourth cycle of the Localizer identification code modulation is suppressed and the station identification Morse code is sent to the DME Keying output terminals. The DME keying output shall employ an isolated, solid state relay with contact resistance lower than 250 ohms, capable of sinking a current of 20 ma and withstanding an open circuit voltage of 50 Vdc.

If DME keying is selected, the keying output shall remain operational even when the Localizer identification is disabled.

In addition to the Morse code keying, the DME keying output shall be selectable to provide a single start signal to initiate operation of the DME's internal identification keyer.

3.3.3.18 Performance of periodic checks and certification. The following parameters shall be readable either from the equipment front panel or from a PMDT connected to the system. These parameters shall also be readable via the RMM interface:

a. Carrier power output (CSB)
b. Sideband power output (SBO)
c. Course 90/150 Hz modulation balance (DDM)
d. Course total 90/150 Hz modulation percentage (SDM)
e. Course width (DDM)
f. 90 Hz and 150 Hz modulation percentage
g. Identification modulation percentage
h. Modulation frequencies.

Additional parameters for dual frequency systems (where applicable):

a. Clearance power output (CSB)
b. Clearance sideband power output (SBO)
c. Clearance modulation balance
d. Clearance total 90/150 Hz modulation percentage (SDM)
e. Clearance 1 DDM
f. Clearance 2 DDM
g. Far Field Monitor modulation balance (DDM)
h. Carrier frequency separation (dual frequency systems only).

For dual transmitter systems, all parameters shall be capable of being displayed for both the main and standby transmitters.

The following maintenance checks shall be available from the front panel or locally connected portable terminal:

a. Monitor alarm, alert, and executive action

b. Automatic transfer to standby equipment (dual transmitter/monitor system only).

3.3.4 Localizer antenna array. The Localizer subsystem will typically include one of the following antenna configurations:

a. Medium aperture, single frequency array for Category I ILS

b. Medium aperture, dual frequency array for Category I/II/III ILS

c. Wide aperture, dual frequency array for Category I/II/III ILS.

3.3.4.1 Localizer antenna equipment supplied. The Localizer antenna subsystem shall include the following components:

a. Broadband (108-112 MHz) prefabricated radiating elements with radomes if required.

b. Mounting base and support masts or poles for each antenna element.

c. Weather-resistant and animal-resistant cable trough or wireway.

d. Closure plates or hole plugs for support masts, cable trough, or wireway if required to prevent exposure of coaxial cables.

e. Weatherproof housing containing distribution and monitoring components.

f. Support masts, cable trough or wireway constructed in a way that will not allow coaxial cables to be exposed.

g. Dual LED obstruction light assemblies in accordance with FAA Advisory Circular AC150/5345-43 with support pole, mounting base, and hardware for each end of the antenna array.

h. Pre-cut low loss, semi-flexible, phase stabilized, coaxial cable with an RF phase temperature coefficient for the cable of ±10 ppm or less and connectors for interconnecting the antenna elements, distribution, and monitoring components,.

i. AC power cable for the obstruction lights, terminating within the distribution/monitor enclosure.

j. All distribution and monitoring stripline or microstrip assemblies, phase shifters, attenuators, detectors, terminal points, power supplies, and any other components necessary to distribute and adjust the RF signals and provide all required information to the Localizer monitor.

Power, RF, and data (if required) cables between the Localizer shelter and distribution/monitor enclosure will be provided by the Government.

3.3.4.2 Frequency range. The complete Localizer antenna system consisting of the stripline or microstrip distribution network(s), antenna array, and stripline or microstrip monitor combining network(s) shall be designed for operation throughout the band of 108 to 112 MHz without retuning.

3.3.4.3 Intercoupling. The isolation between those adjacent antenna elements in the array with the closest spacing, as measured between the input connector of the driven element and the monitor output of the undriven element, shall be at least 26 dB.

3.3.4.4 RF distribution unit. The array shall be furnished with the appropriate stripline or microstrip RF distribution unit(s) to provide the proper current excitation to generate the radiation patterns specified. The nominal input impedance of the carrier (CSB) port(s) and the sideband-only (SBO) port(s) shall be 50 ohms. The voltage standing wave ratio (VSWR) at each of the inputs shall be less than or equal to1.20 over the full operating frequency range and service conditions of temperature and humidity. There shall be at least 30 dB of isolation between the CSB and SBO input ports on the RF distribution unit.

3.3.4.4.1 Convenience outlet and work light. The weatherproof RF distribution/monitor enclosure shall be equipped with a light and a dual or quad AC convenience outlet with a ground fault interrupter. The outlet shall be protected by a weather resistant spring-loaded cover when not in use. The outlet shall be equipped with an on/off switch and shall be protected with a metal, tempered glass, or high impact plastic guard (i.e., not a bare bulb).

3.3.4.5 Horizontal RF radiation pattern characteristics. The antenna array shall consist of identical elements with appropriate spacing and excitation to produce the calculated horizontal radiation patterns described in Table VII and its notes. Pattern shapes shall be calculated based on ideal performance of the proposed distribution network for the antenna array described, with excitation levels set to produce a 3 degree course width. For dual-frequency arrays, the relationship between the calculated course and clearance CSB patterns shall comply with Figure 1, with the clearance array meeting the DDM requirements of paragraph 3.3.4.6.

TABLE VII. Horizontal RF radiation pattern characteristics

CSB Pattern		**SBO Pattern**	
Azimuth Angle (± degrees)	**Signal Level (dB)**	**Azimuth Angle (± degrees)**	**Signal Level (dB)**
Medium Aperture Single Frequency			
0	0	0	-60
2.5	-0.5	0.5	0
10	-10	6	0
40	-20	11	-7
50	-40	36	-12
90	-40	60	-24
		80	-40
		90	-40
Medium Aperture Dual Frequency			
0	0	0	-60
2.5	0	0.5	-10
5	-3	2.5	0
8	-10	5	0
15	-35	8	-7
35	-37	12.5	-25

90	-37	35	-35
		90	-35
Wide Aperture Dual Frequency			
0	0	0	-60
5	-5	0.5	0
15	-45	5	0
35	-45	7.5	-22
90	-45	35	-30
		90	-40

Notes for Table VII:

a. The values in the Table VII describe the upper bounds for the actual CSB and SBO patterns.
b. 0 dB is defined as the maximum amplitude of the CSB and SBO radiation.
c. Maximum CSB amplitude shall occur within 0.1 degree of centerline, maximum SBO amplitude shall occur between 2 and 6 degrees off the centerline.
d. The on-course SBO null shall occur within 0.1 degree of centerline.

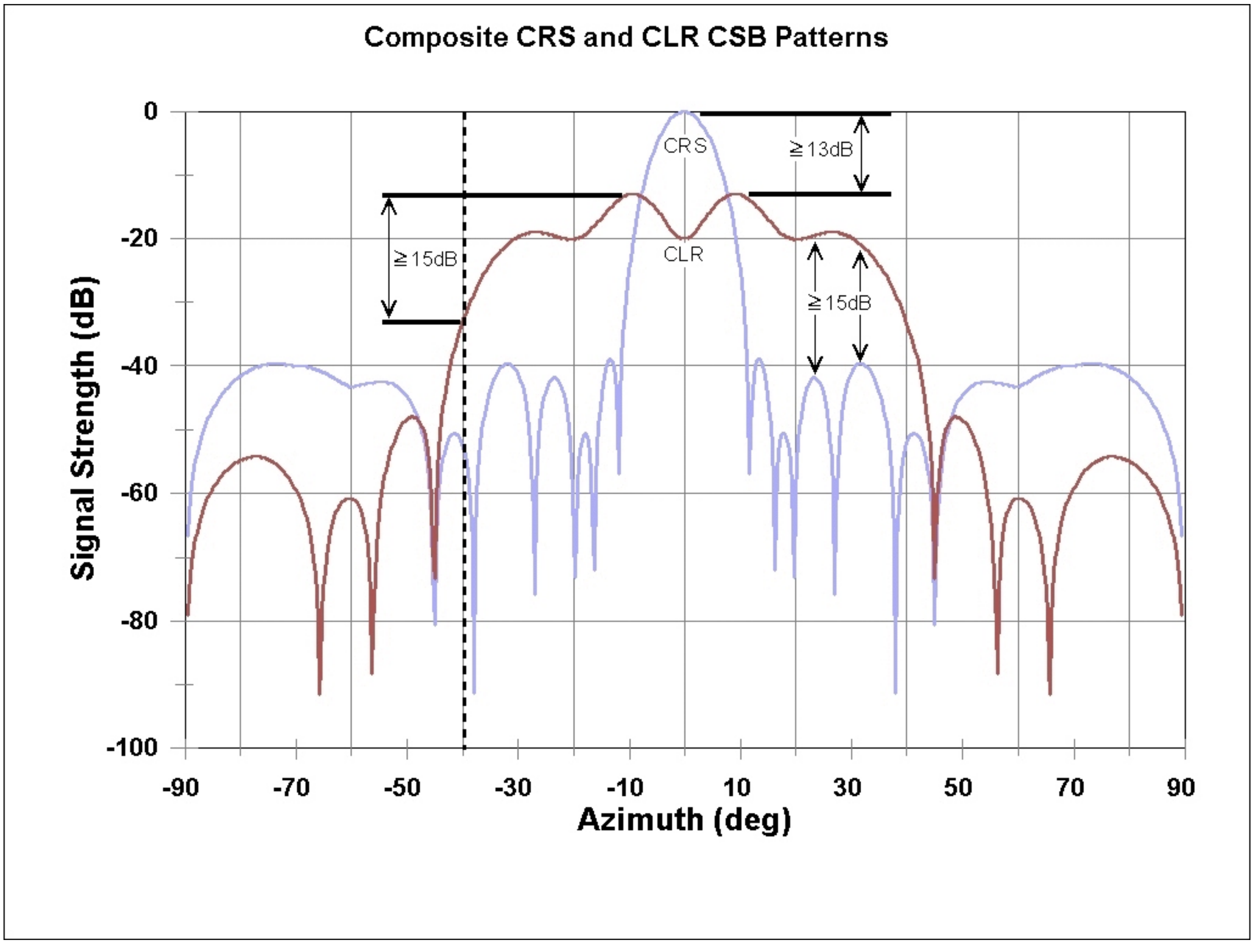

Figure 1. Required amplitude relationships between composite course and clearance CSB patterns

Notes for Figure 1:

a. The 13 dB minimum difference is measured between the maximum CSB course and clearance amplitudes, not necessarily on the centerline.

b. The 15 dB minimum difference between course and clearance CSB amplitudes applies at all angles beyond the first CSB minimum out to 35 degrees off centerline.

3.3.4.6 Clearance array DDM performance. With the course adjusted for 3 degree course width and the Localizer operating normally, SBO sideband amplitude shall not exceed CSB sideband amplitude to at least ±35 degrees from centerline to assure that abnormal case DDM does not result. With the course and clearance transmitters radiating and adjusted to recommended power ratios for a 3 degree course width, the clearance CSB-to-SBO relative pattern shapes shall be such that at least 250 microamperes of clearances exist for dual frequency systems and 210 microamperes of clearance for single frequency systems, beyond the first course CSB null. All other pattern requirements and notes shall be met concurrently.

3.3.4.7 Course width adjustment. Course width adjustment shall be accomplished only by changing the relative power level of the sideband-only (SBO) signal with respect to the carrier signal; no additional equipment or substitution of equipment is permitted.

3.3.4.8 Vertical radiation. The vertical radiation pattern shall be such that coverage requirements are met with the antenna mounted at any height from ground level to a platform of up to 25 feet above level ground.

3.3.4.9 Integral monitoring. The antenna subsystem shall be equipped for integral monitoring, requiring no external monitor antennas. The Localizer Far-Field Monitor is an independent monitor and is addressed separately.

The integral monitor shall be capable of determining the proper operation (phase and amplitude) of the signal distribution network feeding the antennas in the array as well as the relationship between carrier+sideband and sideband-only power delivered to the antenna from the transmitter. The integral monitor shall also be capable of detecting open or shorted cables between the distribution and combining networks and the antenna elements.

The detector and monitor combining network shall be broadband over the full operating frequency range and shall require no retuning for changes in Localizer operating frequency.

Once gains or attenuations necessary to develop the proper monitor signals are established, no further adjustments shall be required to maintain monitoring over the 4 dB RF power range between the nominal operating level and the RF monitor alarm level.

3.3.4.9.1 Monitoring technique. The derived monitoring signals shall accurately represent the amplitude and phase of signals that would be obtained from dipoles at the monitor azimuths in the unobstructed far field.

3.3.4.9.2 Monitored azimuths. The monitor shall provide separate course and width signals derived from the elements in the Localizer antenna array. For a dual-frequency Localizer, two additional monitor signals shall be generated for the radiated clearance signal.

a. For a single frequency system, the monitor outputs shall correspond to 0 degrees (on-course) and edge-of-course (155 uA).

b. For a dual frequency system, the "On-course" (or "Course") monitor output shall correspond to the nominal on-course azimuth of 0 degrees. The "Off Course" or "Width" output shall correspond to either a site-specific azimuth equal to the edge of course (i.e., 0.155 DDM) or a fixed azimuth of 2 degrees off center.

c. The two clearance monitor outputs of a dual frequency system shall correspond to design azimuths selected to best monitor the array's sensitivity to out-of-tolerance clearance signals; for example, a monitored azimuth that is insensitive to one or more pairs should be complemented by the other monitored azimuth being sensitive to that pair(s) while ensuring that the clearance detectors are well captured on the clearance signals. Typical "monitored" azimuths for the CL signal are approximately 20 degrees and 30 degrees from the course (CSE) centerline.

3.3.4.9.3 In-Line phasing detector. For test and monitoring purposes, provision shall be made for the 90/150 Hz composite audio signal from the integral monitor in-line phasing detector(s) to be available inside the Localizer shelter. Wiring between the antenna subsystem and the shelter will be provided by the FAA.

3.3.4.9.4 Monitor stability. The components of the integral monitoring subsystem shall be designed such that monitor values remain stable over the specified service conditions and once calibrated; the monitor shall require no readjustment for seasonal changes in environmental conditions. The integral monitor shall maintain the following parameter stability under Environment III conditions for portions of the integral monitor subsystem external to the Localizer shelter, and under Environment II conditions for portions of the integral monitor subsystem located inside the shelter:

1. DDM ± 0.002
2. RF amplitude ± 5 percent
3. Modulation ± 1 percent (absolute).

3.3.4.10 Mechanical design and frangibility. The antenna array, cable raceway, and monitor/distribution unit housing shall be designed to collapse under impact from an aircraft imparting 4000 lbs-force of shear force parallel to the runway centerline, with minimal damage to the aircraft. Cables and connectors shall break away upon impact so as to not impede the aircraft. Frangibility break point shall be 3 inches or less above ground as described in FAA Advisory Circular AC 150/5300-13 paragraph 305a(4).

3.3.4.10.1 Array height. The overall height of the array when mounted on the normal support shall be less than or equal to 6 1/2 feet.

3.3.4.10.2 Elevated antenna array support structure. The antenna array shall be capable of being mounted on an elevated support structure.

3.3.4.10.3 Wind and ice loading. The antenna subsystem components shall remain mechanically stable under conditions of a wind velocity of 100 mph with a ½-inch radial coating of clear ice.

3.3.4.10.4 Reflectors or screens. The antenna shall produce the required radiation patterns and characteristics without the use of external reflectors or screens.

3.3.4.10.5 Environmentally resistant design and construction. Radomes, connectors, cable entrances and pass-through, cable troughs, and the distribution/monitor component housing shall be constructed to be resistant to the greatest extent practical to moisture, condensation, insects, and small animals such as mice, gophers, and snakes. Gaskets and screens shall be employed where appropriate, and upward-facing openings shall be avoided wherever possible.

3.3.5 Localizer Monitor. The Localizer subsystem shall be provided with a monitor that provides fault detection by processing the monitor signals derived from the antenna integral monitor. When any of the fault conditions specified in paragraph 3.3.5.3 are detected, shutdown or transfer shall be initiated as detailed in paragraph 3.3.5.4.

The total time between the occurrence of a fault and either stable radiation and monitoring of the standby transmitter or shutdown shall be no greater than 2 seconds for Category III operation, 5 seconds for Category II operation, or 10 seconds for Category I operation. These times include the time required to detect an out-of-tolerance signal and transfer to the standby transmitter or shut down.

The monitor(s) shall have adjustable alarm threshold controls for each of the parameters being monitored. The adjustment range shall allow setting alarm thresholds to narrower tolerances than ICAO requirements.

3.3.5.1 Dual equipment monitoring. A dual equipment localizer subsystem shall be equipped with dual parallel monitors for the radiating course and, if dual frequency, clearance signals such that each of the elsewhere specified monitored parameters is examined by two identical monitor channels. An out-of-tolerance condition detected by both monitors simultaneously shall initiate an equipment transfer or shutdown. If an out-of-tolerance condition is detected by one monitor but not the other, the system shall remain operational and a “Monitor fault” alert shall be generated. In the event that one monitor is removed from service (bypassed), leaving the second monitor active, the remaining monitor shall initiate a transfer or shutdown upon detection of an out-of-tolerance signal.

3.3.5.1.1 Hot standby monitoring. If a hot standby course (and clearance transmitter in dual frequency system) is employed in a dual system, each transmitter shall be monitored for each of the specified monitor parameters while operating into its dummy load. Either a single or dual monitor subsystem for the standby transmitter(s) may be used, at the contractor’s option. The integrity of the ILS shall not be compromised by standby monitor design or accuracy. The accuracy and stability of the standby monitor shall be such that when the standby transmitter is switched to the antenna, its signal, as monitored through the main (on-air) monitor path, will be shown to be within operating tolerance.

3.3.5.2 Single equipment monitoring. A single equipment system has a single monitor with the same characteristics described above; however, rather than transferring to a standby transmitter, the monitor shall execute a system shutdown upon detection of a fault condition.

3.3.5.3 Fault conditions. The monitor shall detect a fault and shall initiate appropriate action as specified in paragraph 3.3.5.4 if any of the following fault conditions occur:

a. A shift of the course position corresponding to 5 percent of the nominal course width for Category I operation, 3.5 percent of the nominal course width for Category II operation or 3 percent of the nominal course width for Category III operation.

b. A change in displacement sensitivity (course width) exceeding 17 percent of nominal for Category I/II and 10 percent of nominal for Category III operation.

c. A radiated DDM of less than 0.155 from the edge-of-course out to 35 degrees.

d. A reduction of radiated Localizer RF power of 1 dB from nominal in either the course or clearance signal.

e. A change of the 90 and 150 Hz modulation percentages outside the 18 to 22 percent limits.

f. Continuous (unkeyed) identification tone for more than 17 seconds.

g. Identification tone absent for more than 17 seconds.

h. Reduction of identification modulation percentage. (Threshold adjustable over the range of 2.5 to 12 percent modulation.)

i. An open or shorted connector or cable between the RF distribution unit and an antenna.

j. An open or shorted connector or cable between an antenna monitor output and the RF monitor combiner unit.

k. For dual frequency localizers a change in the frequency separation of the course and clearance transmitters beyond the limits of 7.5 kHz and 8.5 kHz.

3.3.5.4 Monitor action. The fault conditions listed in paragraph 3.3.5.3, with the following exceptions:

a. Course position (3.3.5.3.a)
b. Course width (3.3.5.3.b)
c. Reduction of radiated RF power (3.3.5.3.d).

shall be configurable for either executive monitor action or to produce a warning or maintenance alert without causing a system shutdown or transfer. The three fault conditions listed above shall always result in the following actions if a fault persists for longer than a preset period of time as specified in paragraph 3.3.5.4.4.

3.3.5.4.1 Single equipment response to monitor alarm.

a. Cease radiation of the out-of-tolerance signal.

b. Initiate a local visual alarm and transmit the alarm indication to the remote control point.

c. Attempt to restart the system 50 seconds after detection of the fault. If the fault is still present after restarting, shut down again and attempt a second restart 5 minutes after the fault was first detected.

d. If the manufacturer's equipment has additional restart features, they shall be capable of being disabled.

e. If a successful restart is obtained, the automatic restart circuitry shall be reset after a period of $\geq$ 4.5 minutes. If a second fault occurs within this period, the "5 minute retry" timer is still in effect and restart will be attempted 5 minutes after the initial fault detection.

f. Any manual (operator initiated) restart initiated within 20 seconds after the detection of a fault shall be inhibited, assuring that a system shut down because of a detected fault will remain off the air for at least 20 seconds.

g. Automatic restart shall be inhibited whenever a PMDT is connected to the system and a user is logged in.

h. The system shall be configurable to disable all automatic restart actions.

3.3.5.4.2 Dual equipment response to monitor alarm.

a. Cause the out-of tolerance Localizer transmitters to cease radiating.

b. Transfer the antenna to the standby transmitters and activate the standby transmitters. If the fault persists for the balance of the preset period of time following transfer, the station shall shut down and inhibit restoration for at least 20 seconds.

c. Following transfer or shutdown, initiate a local visual alarm and transmit the alarm indications to the remote control point.

d. For dual equipment used for Category I service, if the fault persists after transfer to the standby transmitter, the automatic restart sequence as described in paragraph 3.3.5.4.1.c shall commence. If either the 50 second or 5 minute restart attempt is successful, the (previously) main transmitter shall reset, resume operation into the dummy load, and be available for transfer when the next fault is detected by the executive (on-air) monitor. If the 5 minute restart fails, additional automatic restarts, if available and enabled, may be attempted. After the last available restart, if the fault persists, the transmitter shall shut down and require a manual reset to restart.

3.3.5.4.3 Fault detected by a single monitor (dual monitor systems). If only one monitor senses a fault and that fault persists beyond the preset period of time, an indication of the single monitor alarm status shall be transmitted to the remote control point.

3.3.5.4.4 Monitor action delay. The monitor shall have a hold-off period adjustable from 0.3 to 10 seconds during which time shutdown or transfer control is inhibited.

3.3.5.5 Localizer monitor stabilization. Within 0.5 seconds after application of the signal, the monitor shall stabilize and measure the value of the applied signal with an accuracy of ± 25 percent of the alarm threshold for that monitored parameter.

3.3.5.6 Localizer monitor failsafe. The Localizer monitor shall meet the failsafe requirements described in paragraph 3.2.23.

3.3.6 Localizer Far-Field Monitor (FFM) subsystem. Category II/III Localizer equipment shall be equipped with a FFM subsystem to indicate the status of the signal based on an actual field measurement. The primary purpose of the FFM is to assess the effect of transient multipath reflectors such as large airplanes on runways and taxiways. The FFM shall have no executive control over the Localizer; however, FFM status shall be indicated with an indicator light and aural alarm at the Localizer transmitter and any remote equipment status display.

3.3.6.1 FFM general requirements. The Localizer FFM subsystem shall be designed to be installed at the middle or inner Marker Beacon site or in a stand-alone configuration. The FFM subsystem shall consist of the following:

a. Two antennas which, when mounted 6 feet to 25 feet above the ground, provide adequate reception of the Localizer signal by the supplied FFM receiver, and have sufficient front to back ratio to preclude interference from reflections from behind the antenna.

b. A 6- foot high frangible support for each antenna with the frangible breakpoint no higher than 3 inches above the base.

c. Two FFM receivers and processing equipment as specified in paragraph 3.3.6.6.

d. FFM equipment cabinet (as described in paragraph 3.3.6.9).

e. All interconnecting cables (power, control, data, etc.) necessary for installation of the FFM when co-located with a Marker Beacon.

3.3.6.2 Fault conditions. The FFM shall detect any of the following conditions:

a. A shift of the course position corresponding to 3.5 percent of the nominal course width when configured for Category II operation.

b. A shift of the course position corresponding to 3percent of the nominal course width when configured for Category III operation.

c. A reduction in the radiated RF signal.

3.3.6.3 Monitor limit adjustments. The out-of-tolerance limits shall be adjustable from 0.000 to ±0.015 DDM and 0 to -6 dB minimum.

3.3.6.4 Alert status filtering. The FFM subsystem shall be a dual system utilizing two independent receivers and antennas, with software filtering and voting such as to minimize short-term nuisance alerts. Detected signals, which fall out of tolerance at a slow periodic rate such as might be caused by reflections from moving objects, shall be filtered to avoid repeated intermittent alarms. An alert shall be issued only under the following conditions:

a. The same out-of-tolerance condition is detected by both monitors

b. The out-of-tolerance condition persists for a preset period of time, adjustable over the range of 0.5 to 10 seconds.

3.3.6.5 Indication of FFM failure. A failure of the FFM subsystem, including the loss of one of the two monitors or a loss of communication between the FFM and Localizer subsystem or remote status indicator shall result in an indication of the failure on the RSIC display panel.

3.3.6.6 FFM receiver performance. The FFM subsystem receivers shall meet the following requirements over the environmental service conditions:

a. Frequency range: 108 to 112 Mhz.

b. Localizer channel selection by a frequency synthesizer.

c. Desensitization: Application of a 4 volt signal 4 MHz removed from the Localizer carrier frequency does not cause more than a 2 dB reduction in the detected level of a 5 microvolt 30 percent modulated signal at the Localizer carrier frequency.

d. Sensitivity: No more than five micro-volts for 10 dB (S+N)/N, 20 percent modulation, 90 Hz.

e. IF image rejection: 90 dB minimum.

f. Frequency stability: .002 percent.

g. Cross modulation: With an input signal of 5 microvolts, application of an interfering signal of 5 millivolts, modulated at 50 percent and separated from the desired signal by 50 KHz , does not cause no more than 10 percent distortion of the demodulated audio from the desired signal.

h. Selectivity: 15 kHz minimum at -6 dB
35 kHz maximum at -60 dB
60 kHz maximum at -90 dB

i. Input impedance: 50 ohms ±10 ohms.

j. Audio frequency response linearity: Better than 0.1 dB for 20 percent modulation at 90 Hz and 150 Hz.

k. Audio output level: For a 20 microvolt input signal 20 percent modulated at 90 Hz, the audio output level can be varied from 0 to at least 125 percent of the minimum level required by the FFM input. . For any RF signal level between the AGC threshold and 10 millivolts, the detected audio output will vary no more than 3 dB.

l. Detector linearity: The detected audio output is linear over the range of 15 to 40 percent modulation. The DC output derived from the detected audio is constant within 1 dB or the range of 15 to 40 percent modulation.

m. Audio distortion: Less than 5 percent at 90 Hz and 150 Hz for a 30 percent modulated RF input signal with an amplitude between 50 microvolts to 10 millivolts.

n. Transient filtering: Only changes in DDM detected by the FFM receiver which deviate from the nominal value for longer than one second will be output to the FFM monitor.

3.3.6.7 FFM control and status display. The FFM shall provide for the following control and status display functions:

a. A FFM bypass switch to suppress FFM alerts. Activation of the bypass switch energizes the FFM monitor alarm bypass light. This is a local switch. In addition, this function can be controlled remotely from the Localizer or the Remote Control subsystem in the air traffic control tower.

b. The FFM transmits DDM and RF signal strength measurements to the Localizer for status display on the Localizer front panel and numeric display on the Localizer front panel or portable terminal. There is no local display of DDM and RF signal strength as measured by the FFM.

3.3.6.8 Time delay and reset. A delay-before-alert timer to inhibit nuisance alerts shall be incorporated in the FFM. This timer shall start when an out-of-tolerance condition is detected by one or both monitors. The timer shall be automatically reset if, within the preset delay time (nominally 10 seconds), both monitors detect that the signal has returned to within the preset tolerance limits. This time delay shall be adjustable from 5 to 90 seconds.

3.3.6.9 FFM equipment enclosures. The FFM electronics cabinet and battery shelf shall be of aluminum or steel construction, designed to be mounted inside a Marker Beacon subsystem or similar sized equipment shelter. The FFM electronics cabinet shall be vented as required for adequate convection cooling with RF screening as required to meet equipment performance requirements. A 120 VAC 15A duplex convenience outlet shall be installed inside the stand-alone cabinet.

3.3.6.9.1 FFM battery shelf. A rustproof metal battery shelf designed to support the batteries needed to satisfy the power requirements of the FFM shall be provided. The battery shelf shall provide adequate maintenance access, shall provide adequate protection against damage caused by electrolyte leakage, shall provide adequate physical protection for the batteries including protection from a short circuit across the terminals, and shall permit the necessary air flow for ventilation.

3.3.6.9.2 FFM equipment and battery mounting options. If the FFM is designed such that the electronics are normally located within the marker beacon electronics subsystem cabinet, an optional dedicated FFM cabinet with all mounting hardware, cables, and battery shelf shall be provided if ordered. Alternately, the FFM may be housed in its own cabinet. If a stand-alone FFM cabinet is used, it shall be no larger than the Marker Beacon cabinet.

When the FFM is installed in the Marker Beacon cabinet, it is permissible to share a single standby battery and charging system for both subsystems; however, the specified common battery, power supply, and battery charger shall have sufficient capacity to power both the Marker Beacon and FFM electronics for the required length of time, and recharge the battery in the required length of time.

3.4 UHF Glide Slope system configurations (general). This specification describes three Glide Slope configurations differing in the amplitude and phase of the modulated carrier and sideband signals radiated by the antennas; single frequency null reference, single frequency sideband reference, and dual frequency capture effect. In addition, this section describes both single and dual (main and standby) equipment configurations.

Typically Category I installations will employ single equipment in one of the three basic configurations, while Category II/III installations will employ dual equipment in one of the three basic configurations. In addition, a dual frequency Glide Slope shall be able to operate with a Watts Antenna Company End Fire Glide Slope (EFGS) antenna system, providing the necessary interface between the transmitters and EFGS distribution unit as well as between the EFGS monitor and the glide slope equipment monitor functions.

The Glide Slope chassis, cabinet, and card cage shall be mechanically designed and prewired (power, control, data, backplane) to accept additional modules allowing any configuration to be field-convertible to any other configuration including conversion to dual frequency and dual transmitter/monitor configurations.

3.4.1 Glide Slope configurations.

a. Null reference Glide Slope station. A complete null reference Glide Slope station shall consist of the following equipment:

1. Transmitter group with associated modulation, monitor, and control equipment.
2. Complete Glide Slope antenna group consisting of two identical transmitting antennas with monitor probes, associated coaxial cabling, and all antenna mounting hardware and dual obstruction lights.
3. Power dividing networks and monitor combining networks required for null reference RF signal distribution and integral monitoring.
4. For dual equipment only: two transmitters/modulators, two monitors, and an antenna changeover unit to switch the antenna from the main to the standby transmitter.

b. Sideband reference Glide Slope station. A complete sideband reference paragraph 3.4.1(Glide Slope station shall consist of the equipment described in a) with the power divider and monitor combining network appropriate for sideband reference signal distribution.

c. Capture effect Glide Slope station. A complete capture effect Glide Slope shall consist of the following:

1. Transmitter group including course and clearance transmitters with associated modulation, monitor, and control equipment.
2. Complete capture effect Glide Slope antenna group consisting of three identical transmitting antennas with monitor probes, associated coaxial cabling, all antenna mounting hardware and dual obstruction lights.
3. Power dividing networks and monitor combining networks required for capture effect RF signal distribution and integral monitoring.
4. For dual equipment only: two sets (each course and clearance) of transmitters/modulators, two sets of monitors, and an antenna changeover unit to switch the antenna from the main to the standby transmitter.

3.4.2 UHF Glide Slope subsystem performance. The Glide Slope subsystem shall provide guidance in the vertical plane to aircraft in approaches to, and landings at airfields. The radiation from the Glide Slope subsystem produces a composite field pattern that is amplitude modulated by a 90 Hz and 150 Hz tones. The radiation pattern shall be developed to provide a straight line descent path in the vertical plane containing the runway centerline, with the 150 Hz tone predominating below path and the 90 Hz tone predominating above path, to at least an angle equal to 175 percent of the glide angle. The Glide Slope shall be adjustable to produce glide path angles between 2 and 4 degrees. The glide path shall be capable of being maintained to within 4 percent of the commissioned glide path angle for Category III systems and 7.5 percent of the commissioned glide path angle for Category I/II systems.

3.4.2.1 Coverage. With the course and/or clearance transmitter power output reduced to the RF monitor alarm level (-1 dB for Dual Frequency, -3 dB for Single Frequency) the Glide Slope shall provide signal level greater than 15 microvolt, flag current greater than 240 microamps, and a fly-up signal of 150 microamps to allow satisfactory operation with a typical aircraft installation in sectors of 8 degrees in azimuth on each side of the course line of the glide path to a distance of at least 10 nautical miles between 0.5 and 1.75 times the path angle above the horizontal, or to such lower angle down to 0.30 times the path angle as required to safeguard the promulgated glide path procedure. Coverage measurements will be made by a certified FAA flight inspection aircraft.

3.4.2.2 Polarization. Emission from the Glide Slope antenna shall be horizontally polarized.

3.4.2.3 Automatic changeover unit (dual transmitter/monitor systems only). The dual equipment Glide Slope shall be equipped with an automatic changeover unit which is controlled by the monitor. When a fault (out-of-tolerance radiated signal) is detected, the automatic changeover unit shall transfer the antenna from the main to the standby transmitter.

3.4.3 Glide Slope transmitter. A Glide Slope transmitter includes the following major functional components: RF generator, modulator, and monitoring sensors. Specific requirements are given in the following paragraphs.

3.4.3.1 Radio frequency. The Glide Slope transmitter shall be capable of operating on frequencies over the range of 329 MHz to 335 MHz in 0.150 MHz increments. The accuracy of the carrier frequency shall be within ±0.002 percent over the service conditions. For the dual-frequency configuration which employs two transmitters, the two carrier frequencies shall track such that only a single setting is required to select the Glide Slope nominal operating frequency. The two transmitters shall be offset symmetrically about the assigned (channel) frequency, with the frequency difference 8.0 kHz.

3.4.3.2 Modulation. Each of the two modulation tones (90 and 150 Hz) shall modulate the course transmitter carrier to a nominal depth of modulation of 40 percent, and shall be maintained within the limits of 38 and 42 percent.

3.4.3.3 Transmitter output power and adjustments. The Glide Slope course/clearance transmitter(s) shall have sufficient power to meet the coverage requirements as defined in paragraph 3.4.2.1 with the antennas provided and with the system installed at a site, which meet FAA siting requirements. For purposes of testing, the transmitter power output power shall be capable of being reduced below the maximum power output by at least 4 dB without changing the modulation characteristics of the transmitted signal. The output power of the CSB signal shall be adjustable with adjustment resolution of no coarser than 0.1 watts.

When operating at the reduced (-4 dB) power level:

a. Modulation balance shall change by not more than 0.002 DDM
b. Path width shall change by not more than 2 percent
c. Carrier total modulation percentage shall change by not more than 0.5 percent in absolute value (typically 79.5 to 80.5 percent).

3.4.3.4 Transmitter stability. Variations in the following parameters over the service conditions shall be remain within the limits tabulated below throughout all settings of the sideband amplitude control:

a.	Carrier power at carrier output	±5.0 percent
b.	Sideband ratio	±0.5 dB
c.	Carrier modulation	±1.0 % (each tone)
d.	Carrier modulation balance	±0.002 DDM
e.	Sideband balance	±0.5 dB
f.	RF phase between carrier and sideband outputs	±10 degrees
g.	Navigational tone frequency	±1.0 percent
h.	Transmitter frequency	±.002 percent of assigned frequency.

3.4.3.5 Power-on stabilization time. Stability requirements of paragraph 3.4.3.4 shall be met from 0.5 seconds after power-on or transfer between transmitters of a dual transmitter system.

3.4.3.5.1 Hot standby transmitter(s). If Glide Slope subsystem stabilization requirements specified in paragraph 3.4.3.5 cannot be met with the standby transmitter normally inoperative ("cold"), the subsystem shall be designed so that the standby transmitter is continuously operating into a dummy load and is continuously monitored.

3.4.3.6 Transmitter control functions and indicators. Controls and indicators shall be provided as described in paragraph 3.2.3.

3.4.3.7 Frequency control. The transmitter shall be controlled by a crystal-referenced synthesizer adjustable to the assigned Glide Slope frequencies within the nominal frequency range of 328 to 336 MHz. A single frequency Glide Slope shall be on the assigned Glide Slope frequency. For a dual frequency Glide Slope, the course transmitter shall be 4 kHz above the channel frequency and the clearance transmitter shall be 4 kHz below the channel frequency.

3.4.3.8 Audio phase of modulation tones. Audio phase relationship between the 90 Hz and 150 Hz modulation tones is as follows:

a. The relative phase of the 90 Hz and 150 Hz modulation tones of the course transmitter shall be such that the demodulated 90 Hz and 150 Hz waveforms pass through zero in the same direction within 50 microseconds of each other at the common zero crossing. If wavetable or other digitally synthesized methods are used to produce the composite modulation waveform, sample rate and resolution must be sufficient to meet these criteria.

b. The phase of the 150 Hz modulation tone of the clearance transmitter, relative to the 150 Hz modulation tone of the course transmitter shall be phase-locked so that the demodulated waveforms pass through zero in the same direction within 50 microseconds at every zero crossing.

3.4.3.9 Carrier modulation. A control shall be provided to adjust total modulation of the carrier output signals in steps of 0.1 percent or smaller over a minimum range of 72.0 to 88.0 percent for the path transmitter or 68.0 to 88.0 percent for the clearance transmitter.

Adjusting the modulation percentage over this range shall produce a change of no more than 5 degree in RF phase between carrier and sideband outputs, measured over the full range of service conditions. The total modulation balance shall remain constant within ±0.004 DDM throughout the full operating range of the total modulation percentage adjustment.

3.4.3.10 Distortion of demodulated navigation tones. Total harmonic distortion of the detected modulation shall be less than 5 percent measured over the bandwidth of 30 Hz to 4 kHz. In addition, no single multiple of 30 Hz within that range with the exception of 90 Hz and 150 Hz modulation tones shall have an amplitude greater than 4 percent (-28 dB) of the maximum amplitude of the demodulated audio.

3.4.3.11 Modulation balance adjustment. A control shall be provided for precisely adjusting the total modulation balance (ratio between 90 Hz and 150 Hz amplitudes), and for simulating changes in the glide path angle. Adjustment of the modulation balance over a range of ±0.025 DDM shall change the total modulation percentage by not more than 0.1 percent.

3.4.3.12 Sideband amplitude adjustment. A sideband amplitude control shall be provided to enable adjustment of the glide path full sector width over the range of 0.80 degrees to 2.0 degrees for any of the three configurations – null reference, sideband reference, or capture effect. Adjustment of sideband amplitude over this range shall change the carrier to sideband phase relationship by no more than ±5 degrees. The FAA flight inspection procedure typically measures this parameter over a half-sector width which, for purposes of verifying this ICAO requirement, will be extrapolated to the full sector width.

3.4.3.13 RF phase adjustment. A control shall be provided for shifting the RF phase of the signal appearing at the sideband (SBO) output over the range of at least ±30 degrees from the carrier (CSB) signal. Adjustment of this control shall cause the sideband amplitude to change by no more than ±0.25 dB.

3.4.3.14 Carrier signal at sideband output. With the modulator adjusted for optimum conditions, for any combination of settings of the sideband amplitude and sideband phaser control, and over the range of service conditions, the carrier (CSB) power appearing at the sideband (SBO) output shall be 30 dB or more below the carrier power appearing at the carrier (CSB) output.

3.4.3.15 Clearance transmitter (dual-frequency only). The clearance transmitter shall operate in the range of 328 to 336 MHz and shall be capable of being modulated at a frequency of 150 Hz to a depth of 80 percent. A dual system shall include both a main and standby clearance transmitter.

3.4.3.15.1 Clearance transmitter output power. The clearance transmitter carrier output power shall be adjustable down to at least 40 percent (-4 dB) of maximum power. Adjustment over this range shall change the modulation percentage by less than or equal to 2 percent (absolute) for any setting of modulation between 50 and 90 percent.

3.4.3.15.2 Clearance transmitter modulation. A control to adjust the clearance modulation over the range of 50 to 90 percent shall be provided.

3.4.3.15.3 Clearance transmitter on/off control. Clearance transmitter on/off operation shall normally be controlled together with the course transmitter, including manual or automatic changeover to the standby clearance transmitter in a dual system. In addition, a control shall be provided to allow removal of the clearance signal while allowing the course transmitter to continue to radiate and be monitored.

3.4.3.15.4 Clearance transmitter stability and power-on stabilization time. Stability of the clearance transmitter signals and stabilization time shall be identical to that of the course transmitter as specified in paragraphs 3.4.3.4 and 3.4.3.5.

3.4.3.16 Performance of periodic checks and certification. The following parameters shall be readable either from the equipment front panel or from a PMDT connected to the system. These parameters shall also be readable via the RMM interface:

a. Carrier power output (CSB)
b. Sideband power output (SBO)
c. Glide path 90/150 Hz modulation balance (DDM)
d. Path total 90/150 Hz modulation percentage (SDM)
e. Path width (DDM)
f. 90 Hz and 150 Hz modulation percentage
g. Modulation frequencies.

Additional parameters for dual frequency systems:

a. Clearance power output (CSB)
b. Clearance 150 Hz modulation percentage
c. Carrier frequency separation.

For dual transmitter systems, all parameters shall be capable of being displayed for both the main and standby transmitters.

The following maintenance checks shall be available from the front panel or locally connected portable terminal:

a. Monitor alarm, alert, and executive action
b. Automatic transfer to standby equipment (dual transmitter/monitor system only).

3.4.4 Amplitude and phase control unit (APCU). The capture effect and sideband reference Glide Slope configurations shall include an amplitude and phase control unit designed to combine the separate carrier, sideband and (for dual-frequency only) clearance signals from the transmitters and deliver them to the antennas in the proper amplitude and phase relationship.

3.4.4.1 Capture effect RF distribution. The capture effect RF distribution unit shall send the course CSB signal to the lower and middle antennas, the course SBO signal to all three antennas, and the clearance signal to the upper and lower antennas. The nominal amplitude and phase relationships of the capture effect signals shall be as shown in Table VIII.

TABLE VIII. Capture effect RF distribution

Antenna	CSB Output	SBO Output	Clearance Output
Upper	None	-6 dB, 0°	0 dB, 0°
Middle	-6 dB, 180°	0 dB, 180°	None
Lower	0 dB, 0°	-6 dB, 0°	0 dB, 0°
Note: Relative amplitudes and phases apply only to other values in the same column.			

3.4.4.1.1 Capture effect phasers. Adjustable phasers shall be provided in each of the antenna outputs. At the contractor's option, these phasers may be either an integral part of the APCU or external to the APCU subassembly. If the phasers are external, they shall be mounted in the box housing the external RF monitor combining network as specified in paragraph 3.4.5.11.2. Each phaser shall have a range of adjustment of at least ±30 electrical degrees. If a mechanical phaser is provided, there shall be at least 1.5 inches of linear travel on each side of mechanical center. Adjustments shall be in increments of one degree or smaller. Adjustment of the phasers over their full range shall cause no output of the APCU to vary by more than ±0.1 dB.

3.4.4.1.2 Capture effect amplitude. Either fixed ratio or continuously adjustable power divider shall be provided to provide the power ratios to the antennas as defined in Table VIII. The appropriate one of the two following subparagraph applies:

3.4.4.1.2.1 Adjustable power dividers. Adjustment of any power divider through its full range of operation shall cause the established phase relationship between antennas fed from that power divider to change by no more than ±2 degrees.

3.4.4.1.2.2 Reserved

3.4.4.1.3 Capture effect carrier output port isolation. With each phaser and power divider set to midrange, the upper antenna output and the sideband input shall be isolated from the carrier input by 40 dB or greater.

3.4.4.1.4 Capture effect CSB distribution stability. After adjustment under normal operating conditions, the power ratio between the middle and lower antenna outputs shall vary no more than ±0.5 dB over the full range of service conditions. In addition, the phase between the middle and lower antenna outputs shall vary no more than ±5 degrees over the full range of service conditions.

3.4.4.1.5 Capture effect sideband port isolation. With each phaser and power divider set to midrange, the carrier input shall be isolated from the sideband input by 40 dB or greater.

3.4.4.1.6 Capture effect sideband stability. After adjustment under normal operating conditions, the power ratio between any two of the upper, middle, and lower antenna outputs shall vary no more than ±0.5 dB over the full range of service conditions. Additionally, the phase of the sideband signal between any two of the upper, middle, and lower antenna outputs shall vary by no more than ±5 degrees over the full range of service conditions, and the phase of the sideband signal with respect to the carrier signal to the middle and lower antenna outputs shall vary by no more than ±5 degrees over the full range of service conditions.

3.4.4.1.7 Capture effect clearance isolation. With phasers and power dividers set to their center positions, the power at the carrier input, sideband input, and middle antenna output ports shall be 33 dB or more below the power applied to the clearance input.

3.4.4.2 Sideband reference RF distribution. The sideband reference amplitude and phase distribution shall be as shown in Table IX.

TABLE IX. Sideband reference RF distribution

Antenna	CSB Output	SBO Output
Upper	None	0 dB, 180°

Lower	0 dB, 0°	0 dB, 0°
Note: Relative amplitudes and phases apply only to other values in the same column.		

3.4.4.2.1 Sideband reference stability. Amplitude and phase stability of the sideband reference RF distribution unit shall be identical to that of the capture effect distribution unit described in the above paragraphs.

3.4.4.2.2 Sideband reference CSB isolation. With all phasers and power dividers set to midrange, the carrier power at the upper antenna port shall be -40 dB or more relative to the carrier power at the lower antenna port.

3.4.4.3 Null reference RF distribution. Since, for a null reference Glide Slope the CSB and SBO outputs are fed directly to two individual antennas, no distribution network for combining the two signal components is required.

3.4.4.4 Antenna Feedline RF power measurement. For a sideband reference or capture effect Glide Slope, built-in line sections for wattmeter elements shall be provided to monitor both the input and output ports of the APCU. For a null reference Glide Slope, line sections shall be provided at the output of the transmitter. For dual equipment, the input line sections shall follow the transfer relay. These line sections may also be used to implement the power sampling capability required by paragraphs 3.2.10 and 3.2.11.

3.4.4.5 Variable attenuator set. A constant phase variable attenuator shall be provided with each Glide Slope subsystem for test and flight inspection procedures. The attenuator set shall be designed to install in the antenna feedline. Cables for connecting the attenuator shall be provided such that the electrical length of the attenuator plus cables is an integral number of wavelengths long at the glideslope mid-band frequency to preclude significant inter-antenna phase changes when the attenuator is inserted. Attenuation shall be adjustable in 0.2 dB steps or smaller from 0.2 dB to at least 2 dB. The phase shall change by no more than ±10 degrees over the range of attenuation.

3.4.5 Glide Slope antenna array. The dual-frequency Glide Slope antenna array shall consist of three antennas. The single frequency Glide Slope antenna arrays shall consist of two antennas. All antennas shall be identical and interchangeable.

3.4.5.1 Antenna configuration. Each antenna may consist of single or multiple horizontally polarized elements combined with a reflector to meet the required gain and vertical and horizontal pattern requirements. Antenna elements shall be constructed such that they are capable of withstanding temperature, humidity, wind, and ice loading conditions of Environment 3 (Appendix A). Antenna elements and reflectors shall be constructed of the same type of metal to prevent electrolytic action where they join together.

3.4.5.1.1 Antenna snow and ice protection. Antenna radomes (paragraph 3.4.5.12) and heaters (paragraph 3.4.5.13) shall be provided for the purpose of maintaining satisfactory Glide Slope performance during certain snow and icing conditions where deemed appropriate by the FAA for the particular location. Unless specifically recommended or required by the manufacturer, if radomes are installed, heaters will not be used.

3.4.5.2 Polarization. The radiated signal of the antenna shall be horizontally polarized. The vertical component shall be at least 25 dB below the horizontal component as measured in front of the antenna and within ±25 degrees in azimuth of a vertical plane perpendicular to the antenna and passing through the center of the antenna.

3.4.5.3 Gain. The antenna shall have at least 10dB of gain over that of a lossless isotropic radiator when measured in free space at 0 degrees azimuth.

3.4.5.4 Front-to-back ratio. The front-to-back ratio of radiated signal shall be greater than 16 dB.

3.4.5.5 Characteristic impedance. The design center impedance of the components and assemblies shall be 50 ohms.

3.4.5.6 VSWR. The input VSWR of the antenna and/or antenna system shall be less than or equal to1.25 to 1.

3.4.5.7 Coaxial feed/monitor cable and connectors. A 500 foot roll of semi-flexible, low-loss, phase-stable, coaxial cable shall be provided with each Glide Slope system. Military quality, water resistant, constant-phase coaxial connectors shall be provided for termination at both ends of each feed and integral monitor cable. At least two spare coaxial connectors shall be provided.

3.4.5.8 Horizontal pattern requirements. The front hemisphere of the horizontal pattern of the antenna when plotted as illustrated in paragraph 3.4.5.8 (Figure 2) shall be confined within the upper and lower limits specified thereon, and shall not decrease below -22 dB in the range from 20 degrees azimuth to 40 degrees azimuth. The 0 degree reference on Figure 2 shall be the electrical axis of the array (the peak of the beam) determined as midway between the 3 dB points of the measured pattern. The electrical axis, so determined, shall deviate from the mechanical axis by no more than ±2 degrees.

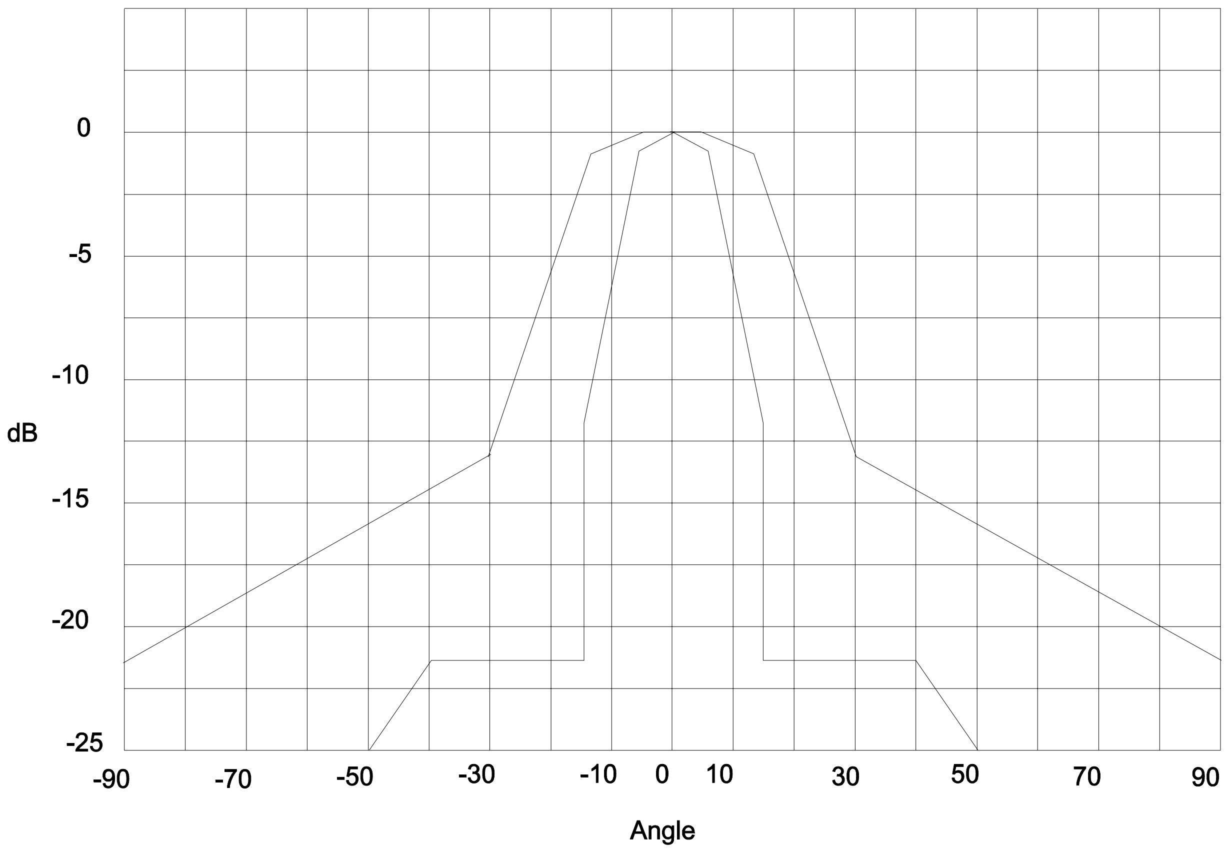

Figure 2. Glide Slope antenna horizontal radiation pattern

3.4.5.9 Vertical pattern requirements. The vertical pattern of the antenna shall be symmetrical around zero degrees elevation and the pattern amplitude shall decrease smoothly in either direction from zero degrees elevation.

3.4.5.10 Multi-element distribution network. If the Glide Slope antenna assembly utilizes multiple radiating elements, a distribution network shall be provided for feeding the individual elements in the phase and amplitude relationships necessary to meet the horizontal radiation pattern requirements. This network shall be weatherproof and mounted within the antenna assembly so as to provide ready accessibility for servicing.

3.4.5.11 Integral monitoring. The integral monitor shall be capable of determining the proper operation (phase and amplitude) of the signal distribution network feeding the antennas in the array as well as the relationship between carrier+sideband and sideband-only power delivered to the antennas from the transmitter. These signals shall represent the path and width of the radiated signal.

3.4.5.11.1 Integral monitor pickups. Each antenna shall include an integral monitor pickup device to sample a portion of the energy radiated by the individual antenna elements. No external antennas shall be required for monitoring the Glide Slope signal. Where the antenna assembly is composed of multiple radiating elements, the output of each element pickup device shall be combined in an RF network with a single output. This combining network shall be mounted in a location on the antenna assembly that is readily accessible for servicing.

3.4.5.11.2 RF monitor combining network. An RF monitor combining network shall be provided to derive path and width signals from the monitor outputs of the radiating antennas. The RF monitor combiner network shall be mounted in the interior of the Glide Slope shelter.

3.4.5.11.3 Integral monitor stability. The components of the integral monitoring subsystem shall be designed such that monitor values remain stable over the specified service conditions and once calibrated, the monitor shall not require readjustment for changes in environmental conditions. The integral monitor shall maintain the following parameter stability under the full range of service conditions:

a.	Phase	± 5 degrees, excluding cables
b.	DDM	± 0.002
c.	RF amplitude	± 5 percent
d.	Modulation	± 1 percent (absolute).

3.4.5.12 Antenna radomes. Radomes to protect the antenna elements from snow and ice accumulation shall be provided. The radomes shall be fabricated from a material which is resistant to heat, cold, fungus growth, bird droppings, and ultraviolet (solar) radiation. All performance requirements of the antenna system shall be met with and without the radomes installed.

3.4.5.13 Antenna heaters. Heating elements firmly attached to the antenna radiating elements shall be provided. Heater operation shall not affect the radiation and/or monitoring characteristics of the antennas. The heaters shall be isolated electrically from the RF circuitry and shall be protected from damage by the pecking of birds.

3.4.5.13.1 Antenna heater control. Antenna heaters shall be controlled from a thermostat assembly to be mounted on the exterior wall of the Glide Slope shelter. The thermostat shall energize the heaters at a temperature adjustable over the range of at least 0 to 5 degrees Celsius, and shall de-energize the heaters at a temperature below which ice will not accumulate on the antenna elements.

3.4.5.14 Glide Slope antenna tower. The Glide Slope antennas shall be mounted on a self-supporting metal triangular-shaped sectionalized tower. The forward facing side (toward the approach end of the runway) of the tower shall be perpendicular to the runway centerline. Each tower shall include an OSHA compliant ladder meeting the requirements of paragraph 3.2.24.3.

3.4.5.14.1 Antenna mounting. The antennas shall be mounted so as to enable easy adjustment of their vertical position on the tower over the range necessary to produce glide path angles of 2 to 4 degrees. Means shall also be provided to laterally offset the antennas either continuously or in increments of 2 inches or less, by at least 24 inches to either side of the centered position on the tower. It is permissible to satisfy this 24-inch offset requirement by providing alternate sets of mounting holes for the antenna mounting brackets so that a bracket with an 18 inch range of offset adjustment may be mounted either on center or offset by 6 inches to extend the offset range to 24 inches.

3.4.5.14.2 Wind and ice loading. The tower, including the stand-off ladder and work platforms, shall withstand wind velocity up to 100 mph with tower encased in ½ inch of radial ice without taking a permanent set. The top of a 50 foot tower shall deflect no more than 2.5 inches for wind load conditions of 45 mph with the tower encased in ½ inch radial ice and for wind of 56 mph with no ice.

3.4.5.14.3 Obstruction lights. Double LED type L-810 obstruction lights meeting requirements of FAA Advisory Circular AC 150/5345-43E shall be provided at the top of the tower. Accepted devices are listed in Appendix 3 of FAA Advisory Circular AC 150/5345-53B.

3.4.5.14.4 Climbing equipment and work platforms. Towers shall be designed for safe climbing and on-tower work in accordance with applicable OSHA 3124 and ANSI Standards. All ladders, accessories, attachments, and fastenings designed to meet a minimum design single concentrated live load of 300 pounds as per OSHA 29 CFR 1910.27. The following features shall be incorporated into the tower design:

a. A ladder mounted to the outside of the tower on stand-offs sufficiently distant from the tower so that a shoe cannot be caught between the tower rung and tower cross-brace.

b. A T-Rail, or Flat-Bar Type safety climbing rail and associated hardware for use with a safety belt when climbing the ladder in accordance with OSHA 29 1926.502.

c. Anchorage points for tie-off installed at various locations where work and/ or maintenance activities are to be performed. Anchorage points used for attachment of personal fall-arrest equipment are to be independent of any anchorage being used to support or suspend platforms, as per OSHA 29 CFR 1926.502.

d. Work platforms located inside the tower structure nominally four feet below each antenna mounting, constructed from steel grating surrounded by a 4-inch kick panel. The work platforms are to be attached by bolts and can be adjusted in height to accommodate the actual mounting location of the Glide Slope antennas.

3.4.6 Glide Slope monitor subsystem. The Glide Slope shall be provided with a monitor system that provides fault detection by processing the monitor signals derived from the antenna integral monitor subsystem. When any of the fault conditions specified in paragraph 3.4.6.2 are detected, shutdown, or transfer as detailed in paragraph 3.4.6.3 shall be accomplished.

The total time between the occurrence of a fault and either stable radiation and monitoring of the standby transmitter or shutdown shall be no greater than 2 seconds for Category II and Category III or 6 seconds for Category I operation. These times include the time required to detect an out-of-tolerance signal and transfer to the standby transmitter or shut down.

The monitor(s) shall have adjustable alarm threshold controls for each of the parameters being monitored. Adjustment range shall allow setting alarm thresholds to narrower tolerances than ICAO requirements.

3.4.6.1 Dual equipment monitoring. A dual equipment Glide Slope subsystem shall be equipped with dual parallel monitors for the radiating glide path and, if dual frequency, clearance signals such that each of the elsewhere specified monitored parameters is examined by two identical monitor channels. An out-of-tolerance condition detected by both monitors simultaneously shall initiate an equipment transfer or shutdown. If an out-of-tolerance condition is detected by one monitor but not the other, rather than causing a shutdown or transfer, a "Monitor fault" alert shall be generated. In the event that one monitor is removed from service (bypassed), the remaining monitor shall initiate a transfer or shutdown upon detection of an out-of-tolerance signal.

If a hot standby glide path transmitter and clearance transmitter are employed in a dual system, each transmitter shall be monitored for each of the specified monitor parameters while operating into its dummy load. Either a single or dual monitor subsystem for the standby transmitter(s) may be used at the contractor's option. The integrity of the ILS shall not be compromised by the monitor design or accuracy. The accuracy and stability of the standby monitor shall be such that when the standby transmitter is switched to the antenna, its signal, as monitored through the main monitor path, will be within operating tolerance.

3.4.6.2 Fault conditions. The monitor shall detect a fault and shall initiate appropriate action if any of the following occur:

a. A shift of the mean glide path by more than ±0.12 degrees, and a tolerance of ±0.045 times the path angle for angles less than 2.67 degrees.

b. A change in path half sector width exceeding ±0.2 degrees of nominal.

c. A reduction of radiated power of the course transmitter of 1.0 dB from nominal.

d. A change of the 90 and 150 Hz modulation percentages of the course transmitter outside the 38.0 to 42.0 percent limits.

e. A deterioration of the Glide Slope system that would result in an out-of tolerance reduction of the below path clearances.

f. A reduction of the radiated power from the clearance transmitter of 1.25 dB from nominal.

g. A reduction of the 150 Hz modulation of the clearance transmitter by 15 percent.

h. An out-of-tolerance separation between reference (course) and clearance transmitter frequencies.

3.4.6.3. Monitor action. The fault conditions listed in paragraph 3.4.6.2, with the following exceptions shall be configurable for either executive monitor action or to produce a warning or maintenance alert without causing a system shutdown or transfer:

a. Glide path position (3.4.6.2.a)
b. Glide path width (3.4.6.2.b)
c. Reduction of radiated RF power (3.4.6.2.c)
d. Reduction in below-path clearance of a dual-frequency system (3.4.6.2.e).

The four fault conditions listed above shall always result in the following actions if a fault persists for longer than a preset period of time as specified in paragraph 3.4.6.3.2.

3.4.6.3.1 Single equipment response to monitor alarm. For single equipment, if any fault is sensed by the monitor, and the fault persists for a preset period of time as specified in paragraph 3.4.6.3.2, the monitor shall initiate the following actions:

a. Cease radiation of the out-of-tolerance signal.

b. Initiate a local visual alarm and transmit the alarm indication to the remote control point.

c. Attempt to restart the system 50 seconds after detection of the fault. If the fault is still present after restarting, shut down again and attempt a second restart 5 minutes after the fault was first detected.

d. Inhibit attempts to restart manually within 20 seconds.

e. Reset the automatic restart circuitry after a period of ≥4.5 minutes if an automatic restart is successful.

f. The system shall be configurable to disable all automatic restart actions.

If the equipment design provides additional automatic restart attempts beyond 5 minutes after the fault detection, it shall be possible to disable these additional automatic restart attempts.

3.4.6.3.2 Dual equipment response to monitor alarm. For dual equipment, if a fault is sensed in the radiated signal by both monitors of a dual monitor system or the monitor of a single monitor system, and the fault persists for a preset period of time as specified in paragraph 3.4.6.3.2, the monitor shall initiate the following actions:

a. Cause the out-of tolerance Glide Slope transmitters to cease radiating.

b. Transfer the antenna to the standby transmitters and activate the standby transmitters. If the fault persists for the preset period of time following transfer, shut down the station and inhibit restoration for at least 20 seconds.

c. Following transfer or shutdown, initiate a local visual alarm and transmit the alarm indications to the remote control point.

d. For dual equipment used for Category I service, if the fault persists after transfer to the standby transmitter, the automatic restart sequence as described in paragraph 3.4.6.3.1.c shall commence on the standby transmitter. If either the 50 second or 5 minute restart attempt is successful, the (previously) main transmitter shall reset, resume operation into the dummy load, and be available for transfer when the next fault is detected by the executive (on-air) monitor. If the 5 minute restart fails, additional automatic restarts, if available and enabled, may be attempted. After the last available restart, if the fault persists, the transmitter shall shut down and require a manual reset to restart.

3.4.6.3.3 Single monitor fault (dual monitor systems). If only one monitor senses a fault and the fault persists beyond the preset period of time, an indication of the single monitor alarm status shall be transmitted to the remote control point.

3.4.6.3.4 Monitor action delay. The monitor shall have a hold-off period adjustable from 0.3 to 10 seconds, during which time shutdown or transfer control is inhibited.

3.4.6.4 Glide Slope monitor stabilization. Within 0.5 seconds after application of the signal, the monitor shall stabilize and measure the value of the applied signal with an accuracy of ± 25 percent of the alarm threshold for that monitored parameter.

3.4.6.5 Glide Slope monitor failsafe. The Glide Slope monitor shall meet the failsafe requirements described in paragraph 3.2.23.

3.5 VHF Marker Beacon station. A complete single equipment VHF Marker Beacon station shall consist of the following:

a. One transmitter group with associated monitor and modulation equipment.

b. One antenna group and associated cabling, divider networks, connectors, hardware, etc. necessary to connect the transmitter to the antenna array and to mount the antenna to the tower or other support specified herein. The transmitter to antenna array coaxial cable(s) for the inner marker will be provided by the Government.

c. One standby battery power group.

d. Steel antenna support tower for the middle and outer Marker Beacons.

e. Self supporting, frangible support for the inner Marker Beacon, with a frangible breakpoint no higher than 3 inches above the ground.

Middle and outer Marker Beacon towers shall meet mechanical design requirements of paragraph 3.2.24. Inner Marker Beacon antenna support shall meet the mechanical design requirements of paragraph 3.2.24.1 and the frangibility requirements of paragraph 3.3.4.10.

3.5.1 Coverage. The required coverage pattern of each marker beacon shall be elliptically shaped as defined in Table X, with the minor axis oriented along the course centerline. The elliptical shape, with its corresponding major and minor axes, is defined as the locus of points at which the received signal is 1700 micro-volts as measured using a calibrated ILS marker receiver installed in a standard FAA flight inspection aircraft. The marker beacon transmitter power shall be capable of being adjusted to provide the required signal (1700 micro-volts) within the bounds of the minimum and maximum dimensions of the axes. In addition, the vertical coverage of the marker beacon shall be such that the received signal rises to 3000 micro-volts/meter near the center of the ellipse.

In addition, the field strength within the coverage area shall meet the following requirements:

a. Provide an elliptical radiation pattern with its minor axis parallel to the course line when cut by a horizontal plane with a minimum major-to-minor axis ratio of 1.5 to 1.0. For purposes of evaluation, coverage will be measured along the Localizer course line while descending along the commissioned glide path. With the marker beacon power adjusted for the desired coverage pattern, signal strength sufficient to provide an indication on the marker beacon receiver is to extend at least 3000 feet above the station.

b. The major axis width will be sufficient to provide sufficient signal strength to a standard Marker Beacon receiver at the 75 microampere edge-of-course line at the altitude established by the instrument approach procedure established for the runway.

c. Horizontally polarized radiation.

TABLE X. Marker Beacon coverage

Marker Beacon	Measured distance along course centerline ("Minor axis")		Measured distance along 75 µA lines ("Major axis")	
	Minimum (ft)	Maximum (ft)	Minimum (ft)	Maximum (ft)
Inner	340	660	Not measured	Not measured
Middle	675	1325	350	1325
Outer	1350	4000	700	4000

3.5.2 Marker Beacon transmitter. One transmitter shall be furnished for each Marker Beacon station. Each transmitter shall include an RF generator, modulator, tone generator, and identification keyer. A selectable front panel display or meter capable of indicating the DC power supply voltage, critical RF test points including antenna VSWR, modulation percentage, and the monitor output shall be provided for purposes of tuning-up and servicing the transmitter. In lieu of a front panel display or meter, the Marker Beacon may be equipped with a portable terminal interface along with the appropriate application software to display the required information.

3.5.3 Frequency. The marker beacon carrier frequency shall be 75 MHz ±0.002 percent. Capability shall be provided to offset the 75 MHz center frequency by ±4 kHz, with no other change in performance.

3.5.4 Carrier output power. The carrier power output of the transmitter shall be no less than 2.5 watts as measured at a 50 ohm unbalanced resistive load terminating the transmitter output.

3.5.5 Power output adjustment. The power output shall be continuously adjustable from maximum power down to 0.05 watts with adjustment resolution of no coarser than 0.05 watts.

3.5.6 Carrier power output stability. After initial adjustment of the carrier power, the carrier power shall vary no more than ±0.5 dB over the full range of service conditions.

3.5.7 Modulation frequency. The transmitter shall include built-in tone generating and modulating facilities so that it can be modulated at any level from 70 to 97 percent by any of the following selectable frequencies:

a. 400 Hz (Outer Marker)

b. 1300 Hz (Middle Marker)
c. 3000 Hz (Inner Marker).

3.5.8 Modulation harmonic distortion. The total harmonic distortion of the demodulated output shall be equal to or less than 8 percent at rated power output and 95 percent modulation.

3.5.9 Modulation stability. After initial adjustment to 95 percent modulation at rated power output and under normal test conditions, the modulation percentage shall vary no more than ±5 percent over the full range of service conditions. Each modulation frequency shall be within ±1.5 percent of the nominal frequency under normal operating conditions and shall be within ±2.5 percent of the nominal frequency over the full range of service conditions.

3.5.10 Identification keyer. The transmitter shall include solid state electronic keying facilities that key the audio frequency modulation without interruption of the carrier, as follows:

a. Key the outer marker audio modulation frequency (400 Hz) to provide a continuous series of dashes.

b. Key the middle marker audio modulation frequency (1300 Hz) to provide a continuous series of alternate dots and dashes.

c Key the inner marker audio modulation frequency (3000 Hz) to provide a continuous series of dots.

A control shall be provided to select among the following modulation choices: Keyed in the pattern as described above; continuous (unkeyed) modulation at the selected audio frequency; unmodulated carrier.

3.5.10.1 Character timing. Character and dot/dash timing for the Marker Beacon keying shall be the same as that of the Localizer as specified in paragraph 3.3.3.12.

3.5.10.2 Keyer stability. The keying rates shall remain within ±15 percent of the design center values under the service conditions. Transient peaks due to keying shall be less than or equal to 2 percent of the peak amplitude of the normal audio frequency waveform at the modulator output.

3.5.11 Marker Beacon transmitting antenna. The transmitting antenna shall consist of single or multiple elements combined with an integral feed network and reflector(s) as required to meet the specified coverage requirements of paragraph 3.5.1. Mounting shall be such that two technicians can raise or lower the antenna. The height of the middle and outer marker antennas above the ground shall be as required to meet coverage requirements but not limited so as not to penetrate a standard ALSF light plane. The height of the inner Marker Beacon antenna shall be as short as practical, but shall in all cases be less than or equal to 7 feet above the ground.

3.5.12 Marker Beacon monitor. A monitor unit shall provide an alarm indication if the transmitter power output drops by a preset amount or if the identification keying is not correct. The monitor shall incorporate a time delay, adjustable between 5 and 15 seconds, to preclude automatic shutdown for short-term out-of-tolerance conditions. The monitor shall include an integral RF pickup and shall not require an external monitor antenna.

3.5.12.1 Alarm threshold controls. A control for adjusting the alarm threshold for power reduction shall be provided. Capability to validate the power alarm threshold and incorrect keying detection without the use of external test equipment shall be provided.

3.5.12.2 Alarm fault conditions. The RF carrier power monitor threshold shall be adjustable to indicate an alarm over the range of -1.5 to -4 dB of the operating power. The keying monitor shall alarm if the modulation tone is not present or if the modulation is continuous.

3.5.12.3 Monitor shutdown action. When an alarm condition occurs during normal marker operation, the monitor shall be configurable to automatically shut down the transmitter. Following a monitor-initiated shutdown, an automatic attempt to restart shall occur at 50 ± 5 seconds. If the first restart is unsuccessful, a second restart shall be attempted at 15 minutes ±30 seconds after the initial shutdown. Upon successful restart, the Marker Beacon shall automatically return to its normal state. If the Marker Beacon fails two restart attempts, no further automatic restart action need be made. At the manufacturer’s option, additional restarts may be made at intervals of 1 hour for up to 12 hours. A local or remote reset operation shall be required to restart the marker following an automatic shutdown without a successful automatic restart.

3.5.12.4 Remote alarm output. When an alarm occurs, the alarm indicator at the remote status indicator shall be activated.

3.5.12.5 Monitor normal/bypass switch. The Marker Beacon station shall be furnished with a monitor bypass switch to allow for temporary disabling of the automatic restart/shutdown function for maintenance purposes. An indicator light shall illuminate when the automatic shutdown feature is bypassed.

3.5.13 AC power control. A switch and indicator light shall be provided for the control of primary AC power to the Marker Beacon station.

3.5.14 Marker Beacon cabinet. The transmitter, monitor, and battery charger power supply shall be housed in an aluminum or steel cabinet designed to be mounted inside the Marker Beacon station shelter. The cabinet shall be vented as required for adequate convection cooling with (RF) screening as required to meet equipment performance requirements. A duplex convenience outlet shall be installed inside the cabinet and shall be wired for 120 VAC operations.

3.5.15 Performance of periodic checks and certification. The following parameters shall be readable either from the equipment front panel or from a PMDT connected to the system. The following parameters shall also be readable via the RMM interface:

a . RF Carrier Power Level
b. Modulation Level.

3.6 Remote control subsystem (RCS), general. The Remote Control Subsystem consists of two or more units: The Remote Status and Control Unit (RSCU), which is normally installed in the equipment room of an air traffic control tower, and one or more Remote Status and Interlock Control (RSIC) panels. At least one RSIC will be installed in the air traffic operational area of the control tower.

The RSCU shall be of modular design and shall be configurable to accommodate anything from a single equipment Localizer-only partial ILS to a full Category III ILS with three Marker Beacons and Far-Field Monitor.

The RSIC shall be equipped with both input and output (or thru) data ports so that additional units can be daisy-chained together for status display and control at other locations.

Interlocked ON/OFF control of two ILSs (typically at opposing ends of a runway) is controlled by the RSCU. Operating the Runway Select switch (physically located on the RSIC) causes the currently operating Localizer, and Glide Slope if required, to cease radiation and its interlocked ILS equipment to begin radiating.

3.6.1 Remote status and control unit (RSCU). The RSCU provides control and status of the ILS subsystems and status of co-located electronic equipment. The RSCU shall provide the following functional capabilities:

a. An ON/OFF and RESET switch for the Localizer, Glide Slope, and Marker Beacon subsystems and BYPASS of the Localizer FFM if so equipped.

b. Visual indication of the status, including monitor bypassed, of the Localizer, Glide Slope, Far-Field Monitor, and the Marker Beacon subsystems. For dual equipment, visually indicate which transmitter (main or standby) is radiating, and the ready/off status (availability for service) of the alternate transmitter.

c. An aural alarm to indicate a change in the operational and/or environmental status of each subsystem and any monitored co-located equipment.

d. Data to update the status display on the Remote Status and Interlock Control panel (RSIC) upon receiving a status change from any of the runway subsystems including the status of co-located equipment (such DME) connected to the auxiliary status monitor input on a field subsystem. The status data shall contain the following information:

1. Current status and alarm indications of the ILS subsystem and co-located auxiliary equipment.

2. The initial report of an out-of-tolerance condition sensed by the FFM which initiates the FFM alarm timer. FFM status is cleared automatically if the FFM returns to normal status within the preset hold-off period.

e. Send On/Off command to the Localizer, and the Glide Slope if required, when a change to an interlocked runway is initiated from the RSIC.

f. Control of auxiliary channels such as reset command to a co-located DME or NDB.

3.6.1.1 Equipment status display (general). The status of each subsystem connected to the RSCU shall be displayed on its front panel. Green shall be used to indicate NORMAL or ON status, ALARM or OFF status shall be indicated by red, and amber shall be used to indicate abnormal status such as a maintenance alert. An aural alarm shall sound concurrent with any status change of a monitored subsystem. The RSCU shall determine the category of service available based on the availability of the ILS subsystems including the Localizer and Glide Slope subsystems, standby transmitters, and the FFM signal-in-space measurement. Loss of communication between the RSCU and any of the runway equipment or between the RSCU and RSIC shall result in an indication of communication failure.

3.6.1.1.1 Category determination. The RSCU shall be capable of being configured to provide the proper indications for a runway approach that is either Localizer-only, Category I, Category II, or Category III. The RSCU shall interpret Localizer and Glide Slope subsystem operating status to determine the category of operation that the ILS can support based on the transmission of an in-tolerance signal and, for Category II or III operation, a ready standby transmitter and a satisfactory FFM indication. The category of operation information shall be sent to RSIC panel for display. The RSIC shall have indicators for CAT III, CAT II, CAT I, and Localizer Only.

3.6.1.1.2 Category conditions. The following conditions shall be indicated by the state of the category indicators as shown in the Table XI below:

TABLE XI. Category for various conditions (Category II/III-capable systems)

Condition	Cat III	Cat II	Cat I	Loc Only
Localizer and Glide Slope operating normally, main transmitter signal radiating, no monitor alarms or alerts, monitor not bypassed, no communications faults	On	On	On	Off
Localizer operating normally, Glide Slope switched to standby transmitter, all other conditions normal	Blink	Blink	On	Off
Localizer operating on standby transmitter, Glide Slope operating on either main or standby transmitter, all other conditions normal	Off	Blink	On	Off
Monitor mismatch (one monitor showing alarm, the other showing normal) at either Localizer or Glide Slope	Off	On	On	Off
FFM course misalignment alert for longer than the preset period for Cat III operation (nominal 2 seconds)	Off	On	On	Off
FFM course misalignment alert for longer than the preset period for Cat II operation (nominal 5 seconds)	Off	Off	On	Off
Single equipment Localizer and Glide Slope operating normally	Off	Off	On	Off
Glide Slope off, Localizer operating on main or standby transmitter with other conditions normal	Off	Off	Off	On

3.6.1.2 Co-located auxiliary equipment status. The RSCU shall be equipped with an indicator to display the normal/alarm or ON/OFF status of co-located auxiliary equipment such as a DME which has its monitor status output interfaced to the ILS auxiliary monitor input as specified in paragraph 3.2.25. When the auxiliary equipment is operating normally, its status received from the ILS subsystem shall cause an ON indicator to illuminate on that subsystem's status panel. When the auxiliary equipment is off or in alarm status, an OFF indicator shall be illuminated on the RSCU panel. In addition, this status shall be passed to the RSIC for remote indication of the status of the co-located equipment.

3.6.1.3 RSCU response time. The RSCU shall respond to status changes received from the runway equipment within one second of the status change. "Response" is interpreted as executing all required actions and indications: change of status indicators, aural alarm, and change of category indication.

3.6.1.3.1 FFM bypass indication response time. When the FFM bypass command is issued from the RSCU, the FFM BYPASSED indicator on the RSCU and RSIC shall illuminate within one second, and the Category indicator shall change to Category I.

3.6.1.4 Interlock response time. All interlocked subsystems of an interlocked ILS controlled by the RSCU shall switch off within 4 seconds after the Runway Select switch of the RSIC is operated. Appropriate status data for the ILS category, subsystem status, and aural alarms shall be output to the RSIC in one second or less after status information is received from the respective subsystems.

3.6.1.5 Alarms. The RSCU shall be equipped with visual and aural alarms. The volume of the aural alarm shall be fixed. The RSCU shall be equipped with a switch to acknowledge and silence an alarm.

3.6.1.5.1 Power loss alarm. An aural and visual alarm shall indicate that AC power to the RSCU or RSIC has been lost and the unit is operating on standby (battery) power. Primary power loss at the RSCU shall also be indicated by an alarm and indicator on the RSIC.

3.6.1.5.2 Environmental alerts. An aural or visual alert shall indicate when a subsystem has lost commercial AC power and is operating on batteries, when the temperature or obstruction light sensors exceed the user-selected threshold limits, or when the intrusion detector or smoke detector has been activated.

3.6.1.5.3 Alarm and indicator test. A switch on the RSCU shall be provided which sounds the aural alarm and illuminates all of the indicators.

3.6.1.6 Runway identification label. A location shall be provided on the RSCU for a label identifying the runway served by the ILS controlled by that RSCU. The label shall be sized to accommodate three 3/8 to 3/4 inch high alphanumeric characters, at minimum 0-9, L, R, C, and blank. The identification for the runway currently controlled by the RSCU shall be transmitted to the RSIC for display in the ATCT. The remote (RSIC) runway identification display shall change dynamically when interlocked runways are switched at the RSIC or RSCU.

3.6.1.7 Mounting and power requirements. The RSCU shall mount in a standard 19 inch relay rack. Panel height shall be less than or equal to 9 inches and the depth, not including the AC power cord, shall be less than or equal to 15 inches. The allowed space shall include the manufacturer’s recommended standby battery and mounting bracket or shelf. Power requirements shall be less than or equal to 250 watts from a 120 VAC single phase source.

3.6.2 Remote status and interlock control (RSIC). The RSIC shall interface with the RSCU and shall provide indication of the operational-ready status of an ILS as well as controlling the ON/OFF status of the ILS and selecting between two interlocked ILSs.

3.6.2.1 RSIC controls and indicators. The following indicators and controls shall be provided:

3.6.2.1.1 ILS runway selection (interlock). Operating the interlocked runway select control shall send the appropriate command to the RSCU to cause the selected/de-selected ILS subsystems to be activated/de-activated, respectively. The runway number for the ILS which the RSIC is currently controlling and displaying status shall be displayed on the RSIC front panel as three electronically generated characters. Characters shall be at least 0.75 inches in height and shall be readable in sunlight.

3.6.2.1.2 Category status display. The category of operation available for the selected runway based on operating status of ILS equipment in accordance with the requirements specified in paragraph 3.6.1.1.2 and shown in Table XI shall be displayed as a Category indicator. Each category indicator LED shall be labeled with the category and shall be green. An amber Localizer Only indicator shall also be provided

3.6.2.1.3 Display of operating status of ILS and co-located equipment. Status indicators tabulated below in Table XII shall be provided. Indicator(s) for subsystems or co-located equipment not installed (e.g., an Inner Marker for a Category I ILS), including the OFF indicator, shall not be illuminated other than when a Lamp Test is being performed. Localizer and Glide Slope standby equipment status indicators are applicable to dual-equipment only and shall be OFF when the RSIC is used with single equipment.

TABLE XII. Status indicators of ILS and co-located equipment

Equipment	Status	Color	Status	Color	Status	Color
Localizer	Main On	Green	Standby On	Amber	Off	Red
Glide Slope	Main On	Green	Standby On	Amber	Off	Red
Inner Marker	On	Green			Off	Red
Middle Marker	On	Green			Off	Red
Outer Marker	On	Green			Off	Red
Aux 1	On	Green			Off	Red
Aux 2	On	Green			Off	Red
FFM	Normal	Green	Bypassed	Amber	Off/Alarm	Red

When any executive monitor is bypassed, all Category Display indicators shall be OFF and a positive indication of the bypassed state shall be provided by blinking of the red status indicator for the equipment with the bypassed monitor.

3.6.2.1.4 Aural alarm. An aural alarm shall be provided to indicate any status change including a FFM alarm. The aural alarm shall also sound each time the Runway Select interlock switch is operated. The aural alarm shall be loud enough to be heard above the ambient noise of a typical air traffic control tower at a distance of 30 feet.

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3.6.2.1.4.1 Aural alarm volume control. The loudness of the aural alarm shall be adjustable from a recessed front panel control. Reduction of volume to fully OFF shall not be possible with this control.

3.6.2.1.4.2 Aural alarm silence switch. A front panel switch shall be provided to silence the current aural alarm. This shall not be a permanent silence switch, and must be operated to silence the alarm each time a status change is received by the RSIC.

3.6.2.1.5 Lamp dimmer control. A front panel control shall be provided to adjust the intensity of the indicators and selected runway display to suit ambient lighting conditions. At maximum intensity, the indicators shall be visible in bright sunlight, and shall not become invisible in a darkened tower cab at minimum intensity.

3.6.2.1.6 Lamp/alarm test switch. A Lamp/Alarm Test switch shall be provided. When operated, all lamps including those not used for the installed system, and all segments of alphanumeric display(s) shall illuminate at full intensity. The Test switch shall simultaneously cause the aural alarm to sound.

3.6.2.1.7 FFM bypass switch. A switch shall be provided to bypass the FFM, if installed. When the FFM is manually bypassed from the RSIC, the category of operation shall be downgraded to Category I and the appropriate combination of indicators shall illuminate.

3.6.2.1.8 Category display status change delay. A delay adjustable with the range of 0 to 120 seconds shall be provided for the purpose of inhibiting an immediate change in the display of category on the RISC when the FFM indicates an out-of-tolerance condition. If the fault condition has not cleared within the delay time, the category change shall be displayed. Any category change resulting from an alarm of the main or standby monitor shall be displayed without delay.

3.6.2.2. RSIC subassembly. The RSIC assembly shall meet the following requirements:

a. Physical Characteristics: Flush-mounting panel not exceeding 10.50 inches in width, 7 inches in height, and 3 inches in depth, excluding cables and connectors. Cables attached from the rear. Mounting holes provided to allow the panel to be installed securely in a horizontal or vertical wood or metal console. Text labels readable from 10 feet under normal ATCT illumination by an operator with normal vision.

b. The panel surface shall be divided into the following distinctive functional areas:

1. Runway number display and ILS runway select control
2. ILS CATEGORY display
3. Subsystem and co-located equipment status display
4. Far-Field Monitor status and bypass switch
5. Alarm test and silence controls and lamp dimmer.

3.6.2.2.1 RSIC Interfaces. The RSIC shall be equipped with two connectors interfacing with two RSCUs for the purpose of controlling ILS equipment on two interlocked runways. Alternatively, a single RSCU interface connector may be provided if the runway interlocking logic resided at a "primary" RSCU which is connected in turn to a "secondary" RSCU for interlocking, or if a single RSCU is provided which can control two or more ILSs.

Input and output connectors shall be provided for the purpose of daisy-chaining additional RSIC displays for the same runway(s).

Mating connectors for each RSIC shall be provided. Multiple connectors of the same type and gender shall be clearly labeled or keyed to preclude incorrect connections.

3.6.2.3 RSCU-RSIC interconnection. The Government will provide the interconnection between the RSCU and RSIC using GFE cable and contractor-supplied mating connectors. 4-wire telephone grade lines are normally provided and will be assumed sufficient for interconnections unless otherwise specified by the contractor. Category 5 Ethernet cabling is permissible if specified by the contractor. The RSIC shall be capable of operating when connected to the RSCU through at least 500 feet of cable.

3.6.2.4 RSCU-ILS subsystem interconnection. The remote control and status functions shall be accomplished utilizing digital information transmitted over a government-furnished single voice grade balanced telephone line pair connecting the RSCU to the Localizer, the Glide Slope, and each of the Marker Beacons. The actual connection medium at certain airports may be a fiber optic link rather than copper wire, with two-wire conversion hardware supplied at each end by the Government. End-to-end DC continuity cannot be assumed for these connections.

3.6.2.4.1 Radio links. Communication between the ILS subsystems and RSCU shall be possible via a contractor-specified radio link system meeting NTIA requirements rather than via hard wiring. All functions shall be available and all response time requirements shall be met when operating via radio link. If the recommended radio link system requires a unique interface (for example, to power the radio or control half-duplex operation), that interface shall be incorporated in the RSCU and the RSCU interface on the ILS subsystems.

3.6.2.5 Implementation of interlock control. The interlock control shall provide the following:

a. Interlocked control of two ILSs (typically) installed on opposite ends of the same runway such that the two Localizers can never be radiating at the same time. Operation of related Glide slope and marker beacon equipment can be configured to follow the radiation status of the localizer if desired. The switching of two interlocked ILSs is a toggle action with one ON and the other OFF at all times unless disabled at the field site for maintenance.

b. A Runway Select switch on the RSIC panel to control the currently radiating ILS. If multiple RSICs are connected to an RSCU, only one RSIC is capable of controlling the ILSs. Designation of the master (controlling) RSIC is configurable from the RSCU. Other RSICs connected to the RSCU are to have indicator/alarm functions only, with the Runway Select function being inhibited.

c. Compatibility with legacy systems to the extent that the second (interlocked) ILS can be a standard Wilcox/Thales Mark 20. The FAA will assume the responsibility for providing either a Mark 20 ILS or one with a compatible remote control interface.

d. Time delay during runway switching. A single control turns the currently operating ILS equipment OFF and, after a 20-second delay during which neither of the two interlocked ILSs is radiating, switches the interlocked ILS equipment ON. Selection of the active ILS runway by the RSIC Runway Select switch results in the start-up and operation of all subsystems of the ILS configured for interlocking after the fixed time delay.

e. Remote interface for monitoring and control localizers.

3.6.2.6 Remote control subsystem fail-safe and failure modes. A failure of the RSIC, RSCU, or communication between the RSCU and subsystems shall not cause a change in operational state of the ILS subsystems. Additionally, if a failure occurs in communications between the RSCU and an ILS subsystem, operational control shall be automatically disabled from the RSIC.

3.7. ILS monitor receiver subsystem.

3.7.1 ILS monitor receiver general requirements. The ILS Monitor Receiver Subsystem shall be designed to be installed in an Air Traffic Control Tower or other location on or near the airport designated as the point of ILS status monitoring. The ILS Monitor Receiver Subsystem consists of the following:

a. Receiver(s) and processing equipment
b. Remote status unit

c. Antenna(s)
d. All connectors necessary for installation of the subsystem.

3.7.2 Receiver(s) and processing equipment. The receiver(s) and processing equipment shall be mounted in a standard 19-inch equipment rack. The receiver(s) and processing equipment shall operate from 120 volts, 60-hertz commercial power. The receiver and processing equipment shall accept an RF connection to the antenna(s). The receiver and processing equipment shall provide appropriate status and alert information to its remote status unit as specified in paragraph 3.7.5.

3.7.3 ILS monitor receiver subsystem function. The ILS Monitor Receiver shall monitor the Localizer and Glide Slope RF signal levels from a selected ILS. The Monitor Receiver subsystem shall detect RF signal level from the Localizer or Glide Slope, and shall cause an aural and visual alarm when the level falls below a preset threshold. The RF level alarm shall be adjustable from 0.5 dB to 4.0 dB below the normal received signal level. The receiver should have a delay timer to reduce nuisance alarms because of short-term RF fluctuations. The time delay shall be adjustable from 0 to 5 seconds.

3.7.4 ILS monitor receiver performance. The ILS Monitor Receiver subsystem shall contain receiver(s) designed to meet the following requirements over the environmental service conditions:

a. Frequency range: 108 to 112 MHz and 328 to 336 MHz

b. Sensitivity: Five microvolts for 10 dB (Signal+Noise)/Noise

c. IF image rejection: 90 dB minimum

d. Frequency stability: ± 0.002 percent

e. ILS channel selection by a frequency synthesizer

f. Desensitization: Application of a 4 volt signal removed from the ILS carrier frequency by 4 MHz will not cause more than a 2 dB reduction in the detected amplitude of a 5 microvolt on-frequency 30 percent modulated signal

g. Cross modulation: With an input signal of 5 microvolts, an interfering signal at a level of 5 millivolts, separated from the desired signal by 50 KHz and modulated at 50 percent will cause no more than 10 percent distortion of the detected modulation of the desired signal

h. Selectivity: 15 kHz minimum at -6 dB
35 kHz maximum at -60 dB
60 kHz maximum at -90 dB.

3.7.5 Receiver remote status unit. The remote status unit shall be designed to be mounted in an Airport Traffic Control Tower. Physical dimensions shall be less than or equal to 8 inches (height) by 8 inches (width) by 6 inches (depth). The remote status unit shall provide visual indication of Localizer and Glide Slope status as well as an aural annunciator to indicate an alarm. An Alarm Acknowledge button shall mute the aural alarm.

3.7.6 Antenna(s). Antenna(s) shall provide adequate gain for reception of the Localizer and Glide Slope signal. The antenna(s) shall be mounted on the tower cab with a line-of-sight to the Localizer and Glide Slope being monitored. The exact position of the antenna(s) will be determined locally at the time of installation. The antenna(s) shall mount on a standard 1-1/4 inch rigid steel conduit. The characteristics of the antenna(s) shall provide satisfactory performance when mounted at a minimum height of 10 feet above the ground. The antenna(s) shall be light enough in weight as not to require guy wires to support the mast.

3.8 ILS remote maintenance monitor (RMM) (general). It is expected that the RMM subsystem will be integrated with the monitor portion of the ILS design. This is permissible as long as the functions and interface protocol described in this section are implemented. The ILS RMM group consists of the various sensors, microprocessor, and software necessary to remotely monitor, control, record, and certify proper operation of the subsystems comprising the instrument landing systems to be furnished under this specification. The RMM group includes a remote monitoring subsystem (RMS) incorporated into each subsystem of the ILS as well as a concentrator which serves as a hub for all RMSs on a runway. The RMM shall use the Simple Network Management Protocol Version 3 (SNMPv3) and shall be designed and manufactured in accordance with the requirements of FAA Interface Control Document (ICD) NAS-IC-51070000-2 and the additional specific requirements cited herein.

3.8.1 RMS concentrator. A concentrator shall be provided so that connection between the remote monitoring facility and all subsystems of a single ILS requires only a single communication line to the concentrator. The concentrator shall be expandable to accommodate additional systems. The RMS Concentrator shall provide a central point for communication between a NIMS Manager (not to be provided under this specification) and up to ten SNMP version 3 compliant NAS subsystems. The concentrator shall communicate with the NIMS Manager at a minimum rate of 100 kilobits per second. The concentrator shall provide the ability to log on to any connected subsystem with a portable maintenance data terminal for the purpose of performing maintenance or certification.

3.8.1.1 Concentrator capacity and expansion capability. The concentrator shall be expandable to have the capability to communicate with 10 additional SNMPv3-compliant NAS subsystems.

3.8.2 Remote monitoring subsystem (RMS). The ILS RMS, with exception of the environmental sensors, shall be an independent but integral part of the Localizer, Glide Slope, Marker Beacon, and Far-Field Monitor. Data monitored by the RMS shall be locally accessible via a portable terminal connected to the terminal port on the ILS equipment.

3.8.2.1 RMS Functions. The ILS RMS shall provide the following functions:

a. Monitor each of the minimum set of performance parameters required to determine the operational status of all ILS subsystems.

b. Process the outputs of each of the monitoring devices as necessary to provide digital data in the appropriate engineering units for the parameter monitored to the NIMS Manager or concentrator in the formats defined in NAS-IC-51070000-2.

c. Process the outputs of each of the monitoring devices to determine alarm and alert status by comparing the monitored outputs to user-defined limits. Provide at least two thresholds for each monitored parameter, an alarm (when the parameter reaches its established limit), and an alert, which is typically 75 percent of the alarm value.

d. In response to a poll (data request message) received from the NIMS Manager, transmit the current value of each parameter in the group or groups of parameters indicated by the content of the request message. A data request may identify a single parameter, an entire preprogrammed list of parameters, a group of randomly selected parameters, or all groups of the monitored parameters.

e. A "text pass-through" function enabling the exchange of text messages up to 4000 characters in length between a connected portable terminal and the NIMS Manager.

f. Time stamping and local storage of the current status of alarms and alerts, data values, alarm and alert thresholds, and sufficient alarm and alert history necessary to analyze the system performance for diagnostic and maintenance purposes. Fault history shall include the last normal parameter values and the post-fault (prior to shutdown) parameter values for the three most recent system faults. At least 50 events, stored in a first-in-first-out sequence, are to be available for retrieval.

g. Expandable memory to increase the storage capacity to 150 percent of that required to meet the requirements specified herein. Expansion may be accomplished either by initial design (providing at least 50 percent unused memory) or by providing sockets for field-installable memory modules.

. h. A master startup/reset and a master shutdown function to start or stop ILS operation upon the receipt of a remote command.

3.8.3 Alarm and alert message format. Alarm and message formats generated by the subsystem RMSs shall be in accordance with NAS-IC-51070000-2.

3.8.3.1 Alarms. A priority alarm message shall be generated when a failure occurs within an ILS subsystem which causes a loss of service to the user (shutdown). A priority alert message shall be generated when a failure occurs within an ILS subsystem which does not cause a loss of service to the user.

3.8.3.2 Maintenance alerts. Maintenance alerts are intended to minimize outages by alerting appropriate personnel of impending failures. When the current value of the parameter exceeds the established limits, an indication of the maintenance alert condition shall be sent to the NIMS Manager. The thresholds for maintenance alerts shall be changeable locally from the portable terminal or remotely from the NIMS Manager.

3.8.4 Non-volatility. All control settings, operational parameters and limits, initialization data, data files and fault history shall be locally stored in the RMS. Local storage shall be supported with sufficient battery capacity or other technique to ensure the non-volatility of stored data for a period of not less than 90 days. Means shall be provided to transfer stored data to another medium for permanent storage purposes.

3.8.5 RMS data sampling rate. The equipment RMS shall sample each parameter no less frequently than once every second.

3.8.6 Real time clock/calendar. The ILS subsystem shall incorporate a real time clock/calendar with date, hours, minutes, and seconds. The clock may reside either in the basic subsystem software or the specific RMS software. The local system time shall be readable as a data point from the NIMS Manager as well as from a locally connected portable terminal. The clock/calendar shall be adjustable both locally from the portable terminal and remotely from the NIMS Manager. The clock function shall be accurate to within 15 seconds a month. The clock shall be supported by a battery independent of the subsystem backup power, and a fresh clock battery shall be capable of maintaining the clock time for at least 180 days.

3.8.7 ILS equipment fault diagnostics. The RMS shall contain the functions necessary to perform fault diagnosis to the LRU level. Upon command, the RMS initiates ILS diagnostic programs and provides the identity of the faulty LRU. Any fault detected by the internal diagnostics is to be isolated to not more than two LRUs. These diagnostics isolate a fault to a single LRU correctly 95 percent of the time.
The resulting fault data shall be stored in memory and shall be accessible via the terminal interface at the RMS or the NIMS Manager. Manually initiated diagnostics shall be available from the portable terminal and NIMS Manager to offer more detailed information on the subsystem status to aid the maintenance process.

3.8.8 Spare input/output capacity. The Localizer and Glide Slope RMS shall provide at least ten spare analog inputs, two spare digital inputs and two spare digital outputs. Each Marker Beacon RMS shall provide a minimum of four spare analog inputs and four digital outputs. All spare analog inputs shall provide user-configurable alarm and pre-alarm (alert) thresholds identical in function to those of the standard monitored parameters. Data, alarms, and alerts from the spare inputs shall be transmitted to the NIMS manager upon demand. Specific requirements for the spare inputs and outputs are as follows:

a. Analog inputs:

1. Input range: Bipolar, -5.000 to +5.000 vdc with respect to input ground
2. Accuracy: ±5 percent of reading or ±0.01 volt whichever is numerically smaller
3. Input impedance: 20 kilo-ohms or greater
4. A/D converter resolution: 1 part in 1000.

b. Digital inputs:

1. TTL, low = 0.0 to +0.8 volts, high = +2.0 to +5.5 volts.
2. Sense: Programmable such that either high or low represents alarm, with the opposite sense representing normal.

c. Digital outputs:

1. TTL with the same voltage limits as the digital inputs
2. Current sink capacity: 24 ma minimum.

3.8.9 Environmental monitoring. The following sensors together with all necessary connectors, terminal boards, enclosures, mounting hardware and installation instructions shall be furnished with each equipment RMS as specified below. Measurements from the sensors shall be processed by the RMSs for transmission to the NIMS Manager and for output locally via the terminal interface.

a. Intrusion detector (Localizer, Glide Slope, and each Marker Beacon subsystem)

b. Smoke detector (Localizer, Glide Slope, and each Marker Beacon subsystem)

c. Obstruction lights (Localizer and Glide Slope subsystems)

d. AC Power (Each ILS subsystem)

e. Temperature (Localizer, Glide Slope, and each Marker Beacon subsystems)

3.8.9.1 Intrusion detector. The intrusion detector shall detect the opening of the door of the ILS shelter. The RMS building security timer shall start when the detector senses that the door has been open for 0.25 seconds. If a portable terminal is not connected to the terminal interface within 5 minutes, the RMS shall indicate that the building security parameter is in alarm and shall generate a priority alarm message. If the portable terminal is connected and a terminal connected message command is received within 5 minutes, the building security parameter shall return to normal. If after being connected, the portable terminal is disconnected from the terminal interface, the RMS shall inhibit sensing a building security alarm for a period of 5 minutes prior to resuming normal monitoring of the building security parameter. Capability to arm and disarm (bypass) the intrusion detector through remote commands shall be provided.

3.8.9.2 Smoke detector. The Localizer, Glide Slope, Marker Beacon, and FFM (if not co-located with a Marker Beacon) shall be furnished with an ionization type smoke detector powered from the facility equipment and not requiring batteries and meeting the requirements of Underwriters Laboratories, Inc. Standard 268 and bearing the U.L. label showing compliance. Activation of the smoke detector shall generate a priority alarm message.

3.8.9.3 Obstruction light current sensors. The Localizer and Glide Slope subsystems shall be furnished with obstruction light current sensors of a current range appropriate for the obstruction lights provided with the system. The RMS shall be capable of detecting a current change representing the failure of a single lamp. Failure of one lamp shall constitute a pre-alarm while failure of two or more lamps shall constitute an alarm.

3.8.9.4 AC power sensor. Each ILS subsystem shall be equipped with an AC power sensor. The AC power sensor shall detect the presence or absence of AC power applied to the ILS equipment. The RMS shall respond to a change of the AC power status by transmitting the AC power alarm message to the NIMS Manager.

3.8.9.5 Temperature sensors. The Localizer shelter shall be equipped with both an inside and outside temperature sensor. All other subsystem shelters shall be equipped with an inside temperature sensor only. The sensors shall measure temperature over the range of –10 to +70 degrees C with an accuracy of ±4 degrees or better. The RMS shall be programmable with upper and lower temperature alarm limits. Exceeding the temperature alarm limits shall cause a temperature alarm message to be transmitted to the NIMS manager.

3.8.10 RMS security. Log-on security shall be implemented to ensure that only authorized personnel can enter RMS commands either locally or from a portable terminal connected to the Concentrator.

3.8.10.1 Security implementation. The RMS security design shall:

a. Include a standard initial log-on procedure for factory-delivered systems. The procedure provides first time access at any ILS subsystem for the purpose of assigning passwords and security access levels. While it is the intent of the Government to delete this initial user and password data as soon as a Level 3 security user is established, a method of restoring the factory log-on ID and password must be included.

b. Employ assigned user IDs and passwords containing up to 16 alphanumeric characters with a minimum of 24 total ID/password combinations stored in the RMS non-volatile memory. When logging in, the User ID is echoed to the portable terminal as non-alphanumeric characters.

c. In response to entry of an invalid ID or password, display an error message to the terminal, terminate the log-in procedure (i.e., not prompt the user to try again), and return to its idle (wait) state.

d. Provide a message identifying the logged-in user to the NIMS Manager for all validated access entries and send a log-off message when the user logs off.

e. Inhibit the transmission of alarm or alert messages to the NIMS Manager after the initial log-in identification, during the time a second or third security level user is logged in.

f. Automatically log off the user if the terminal has been idle for more than 15 minutes or if there is no terminal activity within 15 minutes following the completion of a user-initiated test.

3.8.10.2 Security level definitions. Security levels for the RMS are defined as follows:

a. Level 1: Entry of a valid User ID and password shall allow READ ONLY access/display of subsystem status, configuration, and monitored system parameters. The user has no control over the ILS subsystem.

b. Level 2: Entry of a valid user ID and password shall enable read and write access/display of all subsystem functions and changeable parameters.

c. Level 3: Entry of a valid user ID and password shall enable level 2 capabilities and also provide the ability to assign user IDs and passwords.

3.8.11 RMS data filtering. All measurements and control functions available from the front panel or maintenance data terminal shall be available remotely. Capability to filter or disable any of these parameters or controls shall be possible via local configuration so that they are not transmitted to the remote location nor are commands sent from the remote location executed by the local system.

Filtering shall be implemented via a configuration table listing each parameter monitored by the RMS. Each parameter shall be selectable to send a pre-alarm (alert) message, an alarm message, or no message. A similar configuration table for each remote control function shall allow the enabling or disabling remote control by the NIMS Manager.

3.8.12 RMS FailSafe. The RMS design shall be failsafe such that failures in the RMS function cannot cause failures in, or in any way degrade, the air traffic operational capabilities of the ILS.

4. VERIFICATION

4.1 Verification methods. Verification of requirements will be performed by one of the following methods.

4.1.1 Test – A laboratory or field test with measured data showing that performance requirements are met within the tolerances established by the specification or, if not specified, in the manufacturer's government-approved test procedures.

4.1.1.1 Design qualification test – Test to verify that the design will meet the specified requirements. Since design requirements are to be met over service conditions, design qualification tests are to be performed over service conditions.

4.1.1.2 Production test – Test performed as part of factory acceptance before delivery.

4.1.1.3 Type test – A test performed on selected units throughout the production cycle to verify that initial design requirements are still met. Since design requirements are to be met over service conditions, type tests are to be performed over service conditions.

4.1.1.4 Operational test – A test performed in the field by the FAA which may or may not involve airborne measurements. The Contractor may witness these tests and is responsible for fixing deficiencies discovered during these tests, but is not required to participate in this testing.

4.1.2 Demonstration – A laboratory demonstration showing that a required feature is present and performs the required function.

4.1.3 Analysis – Engineering analysis supporting the manufacturer's claim that requirements are met.

4.1.4 Inspection – Visual inspection to verify construction, material, presence of required equipment, controls, and indicators.

4.2 Test location – In general, all design, production, and type testing is performed at the contractor's facility. When purchased parts requiring test are used in the manufacture and assembly of equipment furnished under this specification, the original manufacturer's test data will be acceptable, followed by inspection by the contractor to assure that the supplier's test is valid. Operational testing will be performed by the FAA at a test facility to verify that the supplied equipment meets signal-in-space requirements.

4.3. Verification Requirements Traceability Matrix (VRTM).

Legend:
A – Analysis
D – Demonstration
I – Inspection
T – Test
Flt – FAA Flight Inspection test and measurements
OTE – FAA Operational Testing and Evaluation

Specification Requirements		**Test Level and Method**				**Remarks**
Para. No.	**Title**	**Design**	**Prod**	**Type**	**Oper**	
3.1.1	Electronic equipment, general requirements					
3.2	General system requirements					
3.2.1	System performance					
3.2.2	Equipment physical design and packaging	I			D	
3.2.2.1	Subassemblies	I/D				
3.2.2.2	Equipment cabinets	I				
3.2.2.2.1	Materials, processes, and parts					
3.2.3	Controls and indicators					
3.2.4	Display and adjustment of parameters	D				
3.2.4.1	Use of a portable maintenance data terminal (PMDT)	D				
3.2.5	Parameter resolution	D				
3.2.6	Reserved	D				
3.2.7	Adjustment and storage of entered parameter data	D				
3.2.7.1	Storage of entered data	D				
3.2.8	Reserved					
3.2.9	Electromagnetic interference (EMI) control					
3.2.9.1	Electromagnetic compatibility	T/I				
3.2.10	Transmitter RF power sampling	T/I				
3.2.11	Transmitter internal RF power measurement	T/I				
3.2.12	Voltage regulators	I				
3.2.13	Transient protection	T		T		
3.2.14	Output circuit protection	A/D				
3.2.15	Environmental service conditions	T		T		Tested throughout
3.2.16	Primary power	T				
3.2.17	Standby power	T/D/I	D			
3.2.17.1	Battery disconnect switch and fuse/circuit breaker	D				
3.2.18.1	Corrective maintenance requirements	A/D				
3.2.18.2	Preventive maintenance requirements	A/D				

Specification Requirements		Test Level and Method				
3.2.19	Special tools and test equipment	I				
3.2.20 - 3.2.20.5	Reliability of electronic equipment; Localizer MTBF, Glide Slope MTBF, Marker Beacon MTBF, Localizer Far-Field Monitor MTBF, Remote control subsystem MTBF	A/D				
3.2.21	Continuity of service	A				
3.2.22	Integrity of signal	A				
3.2.23	Failsafe	A/D				
3.2.24	Antenna support structure design	I/A				
3.2.24.1	Marker Beacon and FFM antenna mounting	I/A				
3.2.24.2	Localizer antenna mounting	I/A				
3.2.24.3	Glide Slope tower	I/A				
3.2.24.4	Antenna tower and support finishes	I/A				
3.2.25	Status monitoring of co-located electronic equipment	D				
3.2.25.1	Auxiliary input pass-through					
3.2.26	Dual Equipment	D				
3.2.27	Personnel safety requirements					
3.2.28.1	Data security	T				
3.2.28.2	Physical security	T				
3.3	Localizer equipment requirements	I				
3.3.1	VHF Localizer subsystem	I				
3.3.2	VHF Localizer station performance				Flt	
3.3.2.1 - 3.3.2.5	Coverage, Polarization, Course alignment accuracy, Displacement sensitivity, Course sector width	I/A/D			Flt	
3.3.2.6	Automatic changeover unit	I/D				
3.3.3.	Localizer transmitter	I				
3.3.3.1	Radio frequency	T	T	T		

Specification Requirements		Test Level and Method				
3.3.3.2	Modulation	T	T	T		
3.3.3.3	Identification	D	D		Flt	
3.3.3.4	Transmitter output power and adjustment	T	T	T	Flt	
3.3.3.5	Transmitter stability	T		T		
3.3.3.6	Power-on stabilization time	T		T		
3.3.3.6.1	Hot standby transmitter(s)					
3.3.3.7	Transmitter control functions and indicators	I				
3.3.3.8	Audio phase of modulation tones	A/T				
3.3.3.9	Carrier modulation	D/T	T			
3.3.3.10	Distortion of demodulated navigation tones	T		T		
3.3.3.11	Modulation balance adjustment	D/T	T			
3.3.3.12	Identification keying	T/D	D			
3.3.3.13	Sideband amplitude adjustment	T	T	T		
3.3.3.14	RF phase adjustment	T	T	T		
3.3.3.15	Carrier signal at sideband output	T	T	T		
3.3.3.16	Power and modulation measurements	D				
3.3.3.17	DME keying output	D			OTE	
3.3.3.18	Performance of periodic checks and certification	D			OTE	
3.3.4.1	Localizer antenna equipment supplied	I				
3.3.4.2	Frequency range	T	T	T		Production test of antenna elements only
3.3.4.3	Intercoupling	T				
3.3.4.4	RF distribution unit	A/T	T	T		VSWR, phase, amplitude
3.3.4.4.1	Convenience outlet and work light	I				
3.3.4.5	Horizontal RF radiation pattern characteristics	A			Flt	
3.3.4.6	Clearance array DDM performance	A			Flt	
3.3.4.7	Course width adjustment	A			Flt	
3.3.4.8	Vertical radiation	A			Flt	
3.3.4.9	Integral monitoring	I/D/T				

Specification Requirements		**Test Level and Method**				
3.3.4.9.1	Monitoring technique	A	T		OTE	Production test to verify proper operation of combining unit
3.3.4.9.2	Monitored azimuths	A/D			OTE	
3.3.4.9.3	In-Line phasing detector	I/D				
3.3.4.9.4	Monitor stability	T/D			OTE	
3.3.4.10 - 3.3.4.10.4	Mechanical design and frangibility, Array height, Elevated antenna array support structure, Wind and ice loading, Reflectors or screens	A/I				
3.3.4.10.5	Environmentally resistant design and construction	A/I				
3.3.5	Localizer monitor	A/D			OTE	
3.3.5.1.	Dual equipment monitoring	I				
3.3.5.1.1	Hot standby monitoring	I				
3.3.5.2	Single equipment monitoring	I				
3.3.5.3	Fault conditions	D				
3.3.5.4 - 3.3.5.4.4	Monitor action, Single equipment response to monitor alarm, Dual equipment response to monitor alarm, Fault detected by a single monitor (dual monitor systems), Monitor action delay	D	D			
3.3.5.5	Localizer monitor stabilization	T		T		
3.3.5.6	Localizer monitor failsafe	A/D				
3.3.6 - 3.3.6.1	Far Field Monitor (general requirements) Localizer Far-Field Monitor (FFM) subsystem	I/A/D			OTE	
3.3.6.2	Fault conditions	T				
3.3.6.3	Monitor limit adjustments	T				
3.3.6.4	Alert status filtering	I/D			OTE	
3.3.6.5	Indication of FFM failure	D			OTE	

Specification Requirements		Test Level and Method				
3.3.6.6	FFM receiver performance	I/T	T	T		Selected items for production test
3.3.6.7	FFM control and status display	D				
3.3.6.8	Time delay and reset	D	D		OTE	
3.3.6.9 - 3.3.6.9.2	FFM equipment enclosures, FFM battery shelf, FFM equipment and battery mounting options	I				
3.4	UHF Glide Slope system configuration (general)	I/D				
3.4.1	Glide Slope configurations	I				
3.4.2	UHF Glide Slope subsystem performance	A			Flt	
3.4.2.1	Coverage	A			Flt	
3.4.2.2	Polarization	I				
3.4.2.3	Automatic changeover unit (dual transmitter/monitor systems only)	I/D				
3.4.3	Glide Slope transmitter	I				
3.4.3.1	Radio frequency	T	T	T		
3.4.3.2	Modulation	T	T	T		
3.4.3.3	Transmitter output power and adjustment	T	T	T	Flt	
3.4.3.4	Transmitter stability	T		T		
3.4.3.5	Power-on stabilization time	T		T		
3.4.3.5.1	Hot standby transmitter(s)					
3.4.3.6	Transmitter control indicator functions	I				
3.4.3.7	Frequency control	I/D				
3.4.3.8	Audio phase of modulation tones	A/T				
3.4.3.9	Carrier modulation	D/T	T			
3.4.3.10	Distortion of the modulation navigation tones	T		T		
3.4.3.11	Modulation balance adjustment	D/T	T			
3.4.3.12	Sideband amplitude adjustment	T	T	T		
3.4.3.13	RF phase adjustment	T	T	T		

Specification Requirements		Test Level and Method				
3.4.3.14	Carrier signal at sideband output	T	T	T		
3.4.3.15	Clearance transmitter (dual frequency only)	I				
3.4.3.15.1	Clearance transmitter output power	T	T	T		
3.4.3.15.2	Clearance transmitter modulation	D				
3.4.3.15.3	Clearance transmitter on/off control	D				
3.4.3.15.4	Clearance transmitter stability and power-on stabilization time	T		T		
3.4.3.16	Performance of periodic checks and certification	D			OTE	
3.4.4	Amplitude and phase control unit (APCU)	I				
3.4.4.1	Capture effect RF distribution	T	T	T*		*Type Test if fixed ratio power dividers are used
3.4.4.1.1	Capture effect phasers	I/T	T			
3.4.4.1.2	Capture effect amplitude	T	T			
3.4.4.1.2.1	Adjustable power dividers	T				
3.4.4.1.2.2	Fixed power dividers	T				
3.4.4.1.3	Capture effect (CE) carrier output port isolation	T	T	T*		*Type Test if fixed ratio power dividers are used
3.4.4.1.4	CE CSB distribution stability	T		T*		*Type Test if fixed ratio power dividers are used
3.4.4.1.5	CE sideband port isolation	T	T	T*		*Type Test if fixed ratio power dividers are used
3.4.4.1.6	CE sideband distribution stability	T	T	T*		*Type Test if fixed ratio power dividers are used
3.4.4.1.7	CE Clearance isolation	T	T	T*		*Type Test if fixed ratio power dividers are used

Specification Requirements		Test Level and Method				
3.4.4.2	Sideband reference RF distribution	T	T	T*		*Type Test if fixed ratio power dividers are used
3.4.4.2.1	Sideband reference stability	T		T*		*Type Test if fixed ratio power dividers are used
3.4.4.2.2	Sideband reference CSB isolation	T	T	T*		*Type Test if fixed ratio power dividers are used
3.4.4.4	Antenna Feedline RF power measurement	I				
3.4.4.5	Variable attenuator set	I/T		T		
3.4.5	Glide Slope antenna array	I				
3.4.5.1	Antenna configuration	I/A				
3.4.5.1.1	Antenna snow and ice protection	I				
3.4.5.2	Polarization	I/A/T				
3.4.5.3	Gain	T				
3.4.5.4	Front-to-back ratio	T				
3.4.5.5	Characteristic Impedance	T				
3.4.5.6	VSWR	T	T			
3.4.5.7	Coaxial feed/monitor cable and connectors		I			
3.4.5.8	Horizontal pattern requirements	T			Flt	
3.4.5.9	Vertical pattern requirements	A			Flt	
3.4.5.10	Multi-element distribution network	I/A				
3.4.5.11	Integral monitoring	A				
3.4.5.11.1	Integral monitor pickups	I/A				
3.4.5.11.2	RF monitor combining network	I				
3.4.5.11.3	Integral monitor stability	T		T		
3.4.5.12	Antenna radomes	I/D				
3.4.5.13	Antenna heaters	I/T	I			
3.4.5.13.1	Antenna heater control	D	I			
3.4.5.14	Glide Slope antenna tower	I	I			
3.4.5.14.1	Antenna mounting	I				
3.4.5.14.2	Wind and ice loading	A				
3.4.5.14.3	Obstruction lights	I	I			

Specification Requirements		Test Level and Method				
3.4.5.14.4	Climbing equipment and work platforms	I	I			
3.4.6	Glide Slope monitor subsystem	A	T			
3.4.6.1	Dual equipment monitoring	D			OTE	
3.4.6.2	Fault conditions	T		T	OTE	
3.4.6.3.	Monitor action	D	D		OTE	
3.4.6.3.1	Single equipment response to monitor alarm	D			OTE	
3.4.6.3.2	Dual equipment response to monitor alarm	T	D		OTE	
3.4.6.3.3	Single monitor fault (dual monitor systems)	T				
3.4.6.3.4	Monitor action delay	T				
3.4.6.4	Glide Slope monitor stabilization	T				
3.4.6.5	Glide Slope monitor failsafe	A/D				
3.5	VHF Marker Beacon station	I				
3.5.1	Coverage	A/T			Flt	Test to verify that power required for coverage is available.
3.5.2	Marker Beacon transmitter	I				
3.5.3	Frequency	T	T	T		
3.5.4	Carrier output power	T	T	T		
3.5.5	Power output adjustment	T	T			
3.5.6	Carrier power output stability	T		T		
3.5.7	Modulation frequency	T	T			
3.5.8	Modulation harmonic distortion	T		T		
3.5.9	Modulation stability	T		T		
3.5.10	Identification keyer	D	D			
3.5.10.1	Character timing	T				
3.5.10.2	Keyer stability	T		T		
3.5.11	Marker Beacon transmitting antenna	I/D	I			
3.5.12	Marker Beacon monitor	D	D			
3.5.12.1	Alarm threshold controls	D	D			
3.5.12.2	Alarm fault conditions	D/T	D			
3.5.12.3	Monitor shutdown action	D/T	D		OTE	

Specification Requirements		Test Level and Method				
3.5.12.4	Remote alarm output	D			OTE	
3.5.12.5	Monitor normal/bypass switch	D	D		OTE	
3.5.13	AC power control	D				
3.5.14	Marker Beacon cabinet	I				
3.5.15	Performance of periodic checks and certification	D			OTE	
3.6	Remote control subsystem (RCS), general	I/D			OTE	
3.6.1	Remote status and control unit (RSCU)	I/D				
3.6.1.1	Equipment status display (general)	D				
3.6.1.1.1	Category determination	I/A				
3.6.1.1.2	Category conditions	D	D			
3.6.1.2	Co-located auxiliary equipment status	I/D	D			
3.6.1.3	RSCU response time	T	D			
3.6.1.3.1	FFM bypass indication response time	T	D			
3.6.1.4	Interlock response time	T	D			
3.6.1.5	Alarms	I/D	D			
3.6.1.5.1	Power loss alarm	D	D			
3.6.1.5.2	Environmental alerts	D	D			
3.6.1.5.3	Alarm and indicator test	D				
3.6.1.6	Runway identification label	I/D	D			
3.6.1.7	Mounting and power requirements	I/T				
3.6.2	Remote status and interlock control (RSIC)	I				
3.6.2.1	RSIC controls and indicators	I/D				
3.6.2.1.1	ILS runway selection (Interlock)	I/D	D			
3.6.2.1.2	Category status display	I/D	D			
3.6.2.1.3	Display of operating status of ILS and co-located equipment	D	D			
3.6.2.1.4	Aural alarm	D	D			
3.6.2.1.4.1	Aural alarm volume control	D	D			
3.6.2.1.4.2	Aural alarm silence switch	D	D			
3.6.2.1.5	Lamp dimmer control	D	D			
3.6.2.1.6	Lamp/alarm test switch	D	D			

Specification Requirements		Test Level and Method				
3.6.2.1.7	FFM bypass switch	D	D			
3.6.2.1.8	Category display status change delay					
3.6.2.2	RSIC subassembly	I				
3.6.2.2.1	RSIC interfaces	I				
3.6.2.3	RSCU-RSIC interconnection	A				
3.6.2.4	RSCU-ILS subsystem interconnection	A				
3.6.2.4.1	Radio links	I/D			OTE	
3.6.2.5	Implementation of interlock control	A/D/T	T		OTE	
3.6.2.6	RCS failsafe and failure modes	D				
3.7.1	ILS monitor receiver general requirements	I				
3.7.2	Receiver(s) and processing equipment	I/D				
3.7.3	ILS monitor receiver subsystem function	I/D/T	T		OTE	
3.7.4	ILS monitor receiver performance	T	T	T		Selected tests for production
3.7.5	Receiver remote status unit	I/D	D			
3.7.6	Antenna(s)	A/I				
3.8	ILS remote maintenance monitor (RMM) (general)	A/T				Test for compliance with SNMPv3 shall be conducted using industry standard software test tools.
3.8.1	RMS concentrator	A/D/T	I			Performance is to be verified with active connections to all ports.

Specification Requirements		Test Level and Method				
3.8.1.1	Concentrator capacity and expansion capability	T				Performance is to be verified with a fully loaded and expanded concentrator using industry standard software test tools.
3.8.2	Remote monitoring subsystem (RMS)	A/D				
3.8.2.1	RMS functions	A/D				Analysis for fail-safe operation
3.8.3	Alarm and alert message format	A/D/T			OTE	
3.8.3.1	Alarms	D	D		OTE	
3.8.3.2	Maintenance alerts	D	D		OTE	
3.8.4	Non-volatility	A/D			OTE	OTE will verify stored fault history
3.8.5	RMS data sampling rate	A/D				
3.8.6	Real time clock/calendar	A/D				Analysis for battery life
3.8.7	ILS equipment fault diagnostics	D			OTE	
3.8.8	Spare input/output capacity	I/D/T	D			
3.8.9	Environmental monitoring	I/D/T	D		OTE	
3.8.9.1	Intrusion detector	D/T	D			
3.8.9.2	Smoke detector	I/D	D			Inspect for approved smoke detector
3.8.9.3	Obstruction light current sensors	D	D			
3.8.9.4	AC power sensor	D	D			
3.8.9.5	Temperature sensors	T	D			
3.8.10	RMS Security	D	D		OTE	OTE for security functions
3.8.10.1	Security implementation					
3.8.10.2	Security level definitions	D				
3.8.11	RMS data filtering	D				
3.8.12	RMS Failsafe	A				

5. PACKAGING

5.1 Packaging. Packaging requirements shall be as specified in the contract or order (see paragraph 6.2 of MIL-STD-961D1).

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory.)

6.1 Definitions. The following terminology used in this specification is defined below.

6.1.1. Abnormal case difference in depth of modulation (DDM). The condition when the amplitude of the received sideband only (SBO) signal exceeds the amplitude of the received carrier sideband (CSB) signal.

6.1.2. Carrier modulation balance. The term "carrier modulation balance" is defined by, and will exist when, the following conditions prevail at the carrier output:

a. Unity ratio between 90 Hz upper and lower sideband signal levels.

b. Unity ratio between 150 Hz upper and lower sideband signal levels.

c. Unity ratio between the total 90 Hz upper and lower sideband signals and the total 150 Hz upper and lower sideband signals.

d. Pure amplitude modulation only, with no frequency or phase modulation components.

The above conditions result in zero DDM at the carrier output.

6.1.3. Carrier plus sideband (CSB). The amplitude modulated ILS signal consisting of the carrier and sideband components of 90 Hz, 150 Hz, and 1020 Hz (localizer only) audio modulation.

6.1.4. Category I/II instrument landing system. An ILS that provides acceptable guidance information from the coverage limits of the ILS to the point where the Localizer course line intersects the glide path at a height of 100 feet (Category I) or 50 feet (Category II) above the horizontal plane containing the runway threshold.

6.1.5. Category III instrument landing system. An ILS that provides acceptable guidance information from the coverage limits of the ILS to, and along, the surface of the runway.

6.1.6. Certification. Certification is the determination and validation that a system, subsystem, or service is providing or is capable of providing the advertised service to the user. Certification includes an independent determination which ascertains the quality of advertised services, and a validation, which officially confirms and documents the determination in the maintenance log.

6.1.7. Certification parameter. Certification parameters are selected critical indicators of the quality of the required advertised services being provided to the user of systems, subsystems, equipment and services.

6.1.8. Continuity of service. That quality which relates to interruption of the radiated signal during any approach. The level of continuity of service of the Localizer and or Glide Slope is expressed in terms of the probability of not losing the radiated guidance signals.

6.1.9. Course line. The locus of points nearest the runway centerline in any horizontal plane at which the DDM is zero.

6.1.10. Difference in depth of modulation (DDM). The percentage modulation depth of the larger signal, minus the percentage modulation depth of the smaller signal, divided by 100.

6.1.11. Displacement sensitivity. The ratio of change in DDM of a guidance signal to the displacement (in the guidance plane being considered) that produced the change.

6.1.12. Dual-frequency configuration. A Localizer or Glide Slope design in which the guidance signal is comprised of two RF carriers within the same receiver channel but sufficiently spaced in frequency so that their difference frequency falls outside the receiver's audio passband. One of these carriers provides a narrow-beam, high accuracy guidance signal while the other carrier provides a lower power clearance signal which will be captured by the receiver outside the limits of coverage of the guidance signals.

6.1.13. Failure. The inability of any part, circuit, assembly, unit or group of the ILS to operate within its normal and previously established operating tolerances constitutes a failure.

6.1.14. Glide path. The locus of points in the vertical plane of the runway centerline with DDM equal to zero and which, is closest to the runway surface.

6.1.15. Glide path angle. The angle between a straight line representing the mean of the ILS glide path, and the horizontal.

6.1.16. Glide path half sector. The sector in the vertical plane, containing the glide path and limited by the loci of points nearest to the glide path at which the DDM is 0.0875.

6.1.17. Glide path sector. The sector in the vertical plane containing the glide path and limited by the loci of points nearest to the glide path at which the DDM is 0.175.

6.1.18. ILS reference datum. A point determined by the intersection of the downward extended straight line glide path with a vertical line that passes through the runway centerline at the threshold.

6.1.19. Integrity of signal. That quality which relates to the trust which can be placed in the correctness of the information supplied by the facility. The level of integrity of the Localizer or the Glide Slope is expressed in terms of the probability that inaccurate guidance signals will be detected and radiation of improper guidance signals will cease.

6.1.20. Interlock. The means for effecting the necessary switching functions to change ILS operations at those locations having Instrument Landing Systems on the opposite end of a single runway from one system to the other, and which prevents simultaneous equipment operation of ILS equipment at both ends of the runway.

6.1.21. Localizer course sector. A sector in the horizontal plane containing the course line and limited by the loci of points nearest the course line along which the DDM is 0.155.

6.1.22. Maintenance data terminal (MDT). An IBM compatible computer running Microsoft Windows 2000 OS for use by qualified maintenance personnel to facilitate equipment setup, measurements, and/or adjustments. Windows 2000 is the FAA's standard operating system at the time of this specification.

6.1.23. Module. A module is defined as two or more parts or components forming a functional assembly which is a portion of a larger assembly or unit. A module is easily removed intact and replaced by plug-in, unsoldering, "quick-disconnect" fastener or equivalent means. It may or may not contain printed circuitry and it may contain active and/or passive devices.

6.1.24. Portable MDT (PMDT). A portable laptop style MDT running Microsoft Windows 2000 OS for use by qualified maintenance personnel to facilitate equipment setup, measurements, and/or adjustments. A portable terminal is typically Government Furnished Equipment (GFE).

6.1.25. Power output. The average power supplied at the transmitter radio frequency (RF) carrier output jack, including the navigational modulation components.

6.1.26. Remote maintenance monitor (RMM). The information provided for maintenance monitoring consists of qualitative and quantitative data on the actual performance and or status of the ILS subsystems including any individual elements thereof. This data may be used for certification, trend analysis or fault isolation purposes. Remote Maintenance Monitoring also includes the on-airport capability to control subsystem operation, control internal diagnostics or testing for verification the operational status, verify and adjust monitor alarm limits and change certain operational characteristics of the subsystems.

6.1.27. Sideband only (SBO). The double sideband suppressed carrier amplitude modulated ILS signal consisting of the sideband components of the 90 Hz, 150 Hz, and 1020 Hz (localizer only) audio modulation.

6.1.28. Sideband balance. The term "sideband balance" is defined by, and will exist when the following conditions prevail at the sideband output:

a. Unity ratio between 90 Hz upper and lower sideband signal levels.

b. Unity ratio between 150 Hz upper and lower sideband signal levels.

c. Unity ratio between the total 90 Hz upper and lower sideband signals and the total 150 Hz upper and lower sideband signals.

6.1.29. Sideband ratio. The ratio of the total 90 Hz and 150 Hz modulated sideband power delivered at the carrier output to the total 90 Hz and 150 Hz modulated sideband power delivered at the sideband output.

6.1.30. Spurious radiation. An emission on a frequency or frequencies which are outside the designed frequency band of the system, and the level of which may be reduced without affecting the corresponding transmission of information. Spurious radiations include harmonic emissions, parasitic emissions, hum, noise and inter-modulation products, but exclude emissions in the immediate vicinity of the necessary band which are a result of the modulation process for the transmission of information (non-spurious sidebands).

6.1.31. Standard Glide Slope signal. An RF carrier, amplitude modulated simultaneously with 90 Hz and 150 Hz signals so that the sum of their separate modulation percentages equals 80 percent with the voltage waves of the 90 Hz and the 150 Hz signals simultaneously passing through zero in the same direction each 1/30 second.

6.1.32. Standard Localizer signal. An RF carrier, amplitude modulated simultaneously with 90 Hz and 150 Hz signal so that the sum of their separate modulation percentages equals 40 percent with the voltage waves of the 90 Hz and 150 Hz signals simultaneously passing through zero in the same direction each 1/30 second.

6.1.33. Stray radiation. The emission or leakage of the fundamental frequency signals from the equipment at points other than from the normal output(s).

6.1.34. Sum of depth of modulation (SDM). The sum of the percentages of 90 and 150 Hertz modulation.

6.1.35. Terminal interface. The terminal interface is the serial communications port to which the MDT or PMDT as specified in paragraph 6.1.24 is connected.

6.1.36. Total modulation balance. The term "total modulation balance" is defined by, and will exist when, the following conditions as defined immediately above prevail:

a. Carrier modulation balance.
b. Sideband balance.

6.2 Marker Beacon identification keying timing. The dot/dash timing for the marker beacon described in paragraph 3.3.13.10 are consistent with the timing which has been used on all markers installed in the United States for the past thirty years. ICAO requirements for timing are somewhat different and not clearly defined for each marker if it is desired to keep a consistent dot and dash length. The FAA has chosen to use the identification keying commonly recognized in the U. S. rather than change to partially comply with ICAO standards.

6.3 FAA ORDERS:

FAA Order 8200.1, United States Flight Inspection Manual.

FAA Order 6750.16, Siting Criteria for Instrument Landing Systems

FAA Order 6750.49, ILS Maintenance Handbook.

FAA Order 3900.19B, Chapter 10; 1003(h).

6.4 ILS compliance to ICAO Annex 10 matrix

ICAO Annex 10 & Att F Para No.	Paragraph Title	FAA-E-2970 Para No.	FAA-E-2852b Para No.	FAA-E-2492/2c Para No.	Documentation
3.1.1	Definitions	6.1	3.2	2-3.2	
3.1.2	Basic Requirements	3.	3.1	2-3.1	
3.1.2.1	Equipment comprising an Instrument Landing System	3.1	3.1	2-3.1	
3.1.3.1	VHF Localizer Station Performance	3.3.2	3.4.3.1	2-3.4.3.1	NAS-SS-1000 Vol III Grd to Air Element
3.1.3.11.1	Monitor Action	3.3.5.4	3.4.3.4.3	2-3.4.3.4.3	NAS-SS-1000 Vol III Grd to Air Element
3.1.3.11.1	Single Equipment response to monitor alarm	3.3.5.4.1		2-3.4.3.4.3	
3.1.3.11.1	Dual Equipment response to monitor alarm	3.3.5.4.2.	3.4.3.4.3	2-3.4.3.4.3	
3.1.3.11.2	Fault Conditions	3.3.5.3	3.4.3.4.2	2-3.4.3.4.2	
3.1.3.11.3.1	Single Equipment Monitoring	3.3.5.2		2-3.4.3.4	
3.1.3.2	Radio Frequency	3.3.3.1	3.4.3.1.1	2-3.4.3.1.1	NAS-SS-1000 Vol III Grd to Air Element
3.1.3.2.2	Polarization	3.3.2.2	3.4.3.1.3	2-3.4.3.1.3	
3.1.3.3.1	Coverage	3.3.2.1	3.4.3.1.2	2-3.4.3.1.2	NAS-SS-1000 Vol III Grd to Air Element
3.1.3.5	Distortion of demodulated navigation tones	3.3.3.10	3.4.3.2.12	2-3.4.3.2.12	
3.1.3.5.1 & 3.1.3.5.2	Modulation	3.3.3.2	3.4.3.1.4	2-3.4.3.1.4	
3.1.3.6	Course Alignment Accuracy	3.3.2.3	3.4.3.1.5	2-3.4.3.1.5	NAS-SS-1000 Vol III Grd to Air Element
3.1.3.7	Displacement Sensitivity	3.3.2.4	3.4.3.1.6	2-3.4.3.1.6	
3.1.3.9	Identification Keyer	3.3.3.12	3.4.3.2.20	2-3.4.3.2.20	
3.1.3.9	Identification	3.3.3.3	3.4.3.1.8	2-3.4.3.1.8	NAS-SS-1000 Vol III Grd to Air Element
3.1.5.1	UHF Glide Slope Subsystem Performance	3.4.2	3.4.4.2	2-3.4.4.2	NAS-SS-1000 Vol III Grd to Air Element
3.1.5.2	Radio Frequency	3.4.3.1	3.4.4.2.1	2-3.4.4.2.1	NAS-SS-1000 Vol III Grd to Air Element
3.1.5.3	Coverage	3.4.2.1	3.4.4.2.3	2-3.4.4.2.3	NAS-SS-1000 Vol III Grd to Air Element
3.1.5.5	Modulation	3.4.3.2	3.4.4.2.4	2-3.4.4.2.4	

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3.1.5.7	Glide Slope Monitor Subsystem	3.4.6	3.4.4.6	2-3.4.4.7 & 7.1	
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	FFM Receiver Performance	3.3.6.6	3.4.8.2	N/A	
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APPENDIX A

Operating Environmental Conditions

A.1 SCOPE

A.1.1 Scope. The appendix details the requirements of FAA-G-2100G paragraph 3.2.1 for operating environment conditions as tailored for this specification. This appendix is mandatory for this specification.

A.2. REQUIREMENTS

A2.1 Requirements. The equipment shall meet the requirements of FAA-G-2100G, paragraph 3.2.1 for operating environment conditions with the following clarifications. Equipment shall be designed to operate in all environments at all altitudes from 0 to 10,000ft above sea level. Equipment designed for use in attended facilities (air traffic control tower cab or equipment room) shall operate in the ambient conditions of Environment I in Table AI. Equipment designed for use in unmanned facilities (equipment shelter) shall operate with the ambient conditions of Environment II. Equipment not housed in shelters shall operate in the ambient conditions of Environment III.

Table A I. Environmental conditions.

Environment[1]	**Temperature (°C)**	**Relative Humidity[3] (%)**	**Wind (mph)**	**Snow Loading**	**Ice Loading**	**Rain**
I	+10 to +50	10 to 80	--		--	--
II	0 to +50	5 to 90	--		--	--
III[4]	-50 to +70[2]	5 to 100	0 to 100	**TBD**	Encased in 1/2" radial thickness clear ice	2"/hour

Notes:
1. I: For equipment installed in an attended facility.
   II: For equipment installed in an unattended facility.
   III: For equipment installed outdoors (antennas, field detectors).
2. Includes 18°C for solar radiation.
3. Above 40°C, the relative humidity shall be based upon a dew point of 40°C.
4. Conformal coating is required.